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GEOPHYSICS.—*Structure of continents and ocean basins.*[1] RICHARD M. FIELD, Princeton University. (Communicated by JOHN A. FLEMING.)

While I consider it an honor, as well as a pleasure, to be asked to address the Philosophical Society of Washington on this most comprehensive subject, I hasten to assure you that I am fully aware of the difficulties of the task, not the least of which are my own inabilities to do full justice to so fundamental and important a problem. Perhaps my principal excuse is that I have had an excellent opportunity to observe the work of my colleagues in geological-geophysical synthesis during the past decade at fairly close range; by that I mean particularly the advantage of taking part in the inception, planning, and execution of several cooperative research programs and expeditions which are directly related to the topic assigned to me for this evening. On the other hand, I do not propose to stress any particular hypothesis as to the origin of continents and ocean basins, but rather to submit to you a historical review of the data and, more particularly, the lack of data which have led geophysicists and geologists to propose certain working hypotheses; for it seems to me that such a review is highly essential at a time when there appears to be a sudden and rapidly increasing cooperation between geophysicists and structural geologists in the attempt to discover the major structures of the lithosphere. There is still, however, some danger that full cooperation may be delayed by misapprehensions as to the proper relative functions of the geophysicist and the geologist in their specific fields.

With the recent development of theoretical geophysics, certain questions have been posed which, although of some theoretical interest, are not highly methodological. Granted that the theoretical geophysicist has the realm of the sublithic portion of the earth practically to himself, the same does not hold true for the so-called "crust," or outer lithosphere. Too often the theoretical geophysicist implies that rocks are merely physical-chemical types of matter,

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without paying any particular attention to the essential, natural structural controls of their origins. For a seismologist to state that a certain layer or zone of the earth "behaves like a granite" does not necessarily lead to the conclusion that it is granite. Or, to put it in another way, if the surface of the suboceanic lithosphere should be proved to have large areas of granite, the geologist would know that these areas represented the roots of profoundly eroded mountain ranges; possibly an ancient pre-Cambrian erosion surface. To the geologist, therefore, a granite "outcrop" suggests a long and complicated structural-erosional (geomorphological), as well as petrological-chemical, history.

The function of the geophysicist is to adapt the principles and techniques of physics and physical chemistry to the solution of geodetic and geological problems. The function of the geologist is to demonstrate what the major structural geological problems are which, in his estimation, particularly require the aid of the geophysicist; and to help the geophysicist interpret the data which he provides. In making this statement I do not wish to imply that geophysics should be merely the handmaiden of geology, and I certainly *do not* wish to imply that geophysics should be the mistress of any pet geological hypothesis. An exceedingly close and sympathetic union is, however, absolutely essential if we are to realize the full potentialities in earth science. The geophysicist, as this title implies, is deeply concerned with the developments of his techniques, including those "border line problems" which require the help of the theoretical and experimental physicist. In a sense, he bridges the gap between the physicist and the geologist. He also has the advantage over the geologist, in that the application of his techniques to the study of materials is subject to relatively accurate and rigid analysis; and he comes nearer to what we might term the mathematical type of scientist. On the other hand, the geologist, by means of his techniques, is able to produce certain fundamental observable data regarding a relatively small quantity of the lithosphere. In almost every case, the broad areal, as well as the downward continuity, of his major structures can not be directly observed, and, therefore, must be inferred from their traces and trends as exposed in the elevated and dissected areas of the continents. Progress in the study of the lithosphere is seriously retarded when the geologist fails to take full advantage of the techniques and data provided by the geophysicist; or, when the geophysicist, in his more deep-seated studies and speculations, fails to appreciate the important surficial data which

have already been provided by the geologist. Further, many geologists do not yet seem to fully realize the essential aid which the geophysicists can render in greatly extending the area, as well as the depth, of geological surveys. This statement applies particularly to approximately five-sevenths of the surface of the globe, which, at the present geological "instant," is covered by water and ice. Naturally, until the last decade, the geologist has had to confine his studies to the continental lithosphere, and in these studies he has relatively recently been greatly aided by the geophysicist. In no branch of earth science has this union of geophysics and structural geology been more effective from the scientific, as well as the economic, point of view than in the locations of ore deposits and oil wells. Those really responsible for the development of the mineral resources of our country have clearly demonstrated the importance of including geophysics as an essential technique in geological surveys.

But what I wish to emphasize particularly this evening is: (1) The outstanding influence which that great *terra incognita*, the suboceanic lithosphere, has had on geologic speculation as a whole; (2) upon what meager data this influence depends; and (3) the future rôle of the geophysicist in helping to provide the data. Since such great responsibility rests upon the geologists, it would indeed be unfortunate if archaic or unnecessary geological hypotheses were to hinder or delude the geophysicist in the application of his talents and methods. As we all know, the principal values of a hypothesis, as well as a theory, are the trends which it suggests for further research; the major difference between a crank and a scientist is that the latter insists upon a "working hypothesis"—one that still further stimulates the critical application of old and the development of new techniques. But we must remember that even geologists are human, and, once having originated or espoused a hypothesis, they are apt to defend it beyond the point where it helps to promote fundamental research.

One hundred years ago, Ehrenberg noted that the calcareous and siliceous tests of microscopic organisms found in deep sea deposits also played an important rôle in the formation of continental deposits. By 1870 most geologists were firmly convinced that the British Cretaceous chalks, limestones, and also the glauconitic and radiolarian deposits, such as those of eastern North America and the San Franciscan area, were originally deposited in oceanic depths. It is important to note that C. E. Dutton gave his important paper on *The causes of regional elevation and subsidence* before the American

Philosophical Society in the spring of 1871. In the spring of 1889, I believe in this very room, Dutton first proposed the theory of isostasy to account for the gradually reversed reliefs of relatively contiguous areas of the face of the earth. It is also important to note that Dutton was primarily a geologist, with only scanty geodetic data at his command, and it was not until Hayford, Pratt, Airy, Bowie, and others had continued the investigation of Dutton's "working hypothesis" by means of the available, gradually increasing, number of geodetic and gravity data that the theory of isostasy may be said to have become a major geophysical-geological hypothesis. The father of the hypothesis was, however, a geologist, not a geophysicist. It is rather surprising how little attention structural geologists paid to the idea of isostasy, with the exception of a few such as Barrell and Lawson, until about twenty-five years ago, when, first in Europe, and then gradually in the United States, the concept of low angle overthrusts, nappes, and relatively great horizontal translocations of the lithosphere, as exemplified in the Scottish Highlands and the Alps, appeared to be in sharp contrast to isostatic principles. During the past twenty years, it has been this battle between the present champion of isostasy, Dr. Bowie, and many of the leading structural geologists of Europe and America, which has served to illustrate the growing importance of the application of pendulum gravity to the solution of major problems in structural geology, as particularly exemplified by the recent studies of Meinesz, Thom, Bucher, Chamberlin, and Longwell.

But, to return to the purely sedimentary, or stratigraphic, aspect of the problem. Gradually, within the last fifty years, paleontologists and stratigraphers have acquired the data which proves that the bulk, if not practically all, of the continental sedimentary formations, including limestones, were laid down in relatively shallow water—certainly not in oceanic depths; and thus quite independent of, and, to a certain extent, in spite of other data, arose the concept of the relative permanency of oceanic basins and continental platforms throughout geologic time. This statement is particularly true in relation to the Atlantic oceanic basin and its continental margins. A growing appreciation of the major relief pattern of the face of the earth, together with relatively meager geological and geophysical data concerning ocean basins, seemed to indicate, according to J. W. Gregory, that the said major relief pattern had "been shaped and distributed in accordance with some ancient, deep-based plan." In 1887 W. L. Green proposed his Tetrahedral Hypothesis, under the title of *Ves-*

tiges of the molten globe, in order to explain the origin and persistency of continental platforms and oceanic basins. This essentially contractional hypothesis, founded on the apparent similarity between the relief pattern of the globe and the geometric principles involved in the gradual evolution of a spherical tetrahedron from an original spheroid, was accepted by many of the leading geologists of his time, and is still included in Hobbs' 1931 edition of *Earth features and their meaning.* I shall not attempt to summarize the many and serious difficulties which the structural geologists discovered in attempting to harmonize a purely contractional hypothesis with their growing data on the structure of the observable portion of the lithosphere, but shall pass on to the epitome, or ultimate goal, of all students of the history of the Earth—paleogeography.

The fundamentals of modern stratigraphical and paleogeographic techniques have been supplied by workers from many lands, but the profound influence of E. O. Ulrich's splendid researches in North American Paleozoic stratigraphy, resulting in 1908 in the production of an excellent series of paleogeographic maps by Charles Schuchert, can not be overestimated. These two outstanding Paleozoic paleogeographers, together with their British and European colleagues, tacitly, and almost unconsciously, accepted the dictum of the permanency of oceanic basins, in spite of the fact that they found considerable difficulty in providing suitable physical means for the essential intercontinental migrations of both marine and terrestrial organisms. May I again remind the audience that the theory of the permanence of oceanic basins was originally proposed by geologists, not by geophysicists. The necessity for the intercontinental migrations of organisms led to the postulates of either "land bridges" or of "rafting," the bulk of the paleogeographers preferring "land bridges." Thus, while diastrophism and the periodic flooding of the continents by shallow seas are accepted by all geologists as the basis for the delimitation of geologic periods, relatively permanent oceanic depressions seem to be required, in order to accommodate the surplus of water which must exist even during the maximum inundations of the continents.

For geologists, the outstanding events of the second decade of the 20th Century were the World War and the Wegener Hypothesis of Drifting Continents. I well remember how a well-known geologist delivered a stirring and satirical denunciation of this hypothesis in 1916 before a relatively small anti-German group at the Harvard Club in Boston. Only a few months later, this same geologist had

become the chief exponent of the Wegener Hypothesis in this country. This is a single example of the irritating and stimulating effect which the Wegener Hypothesis has had on the rank and file of geologists.

Among the many discussions of the Wegener Hypothesis, perhaps the best is that given by Gregory in his presidential address before the Geological Society of London in 1929. Under the title, *The theory of permanent oceans and continents*, he gave an excellent summary of all the physiographic, structural, paleontological, stratigraphical, and paleogeographical evidence both for and against all existing hypotheses on the origin of continents and ocean basins. He clearly recognized the need for the exploration of the sub-Atlantic lithosphere, and concluded his address with the following interesting statement:

> The combined evidence of stratigraphical geology, paleontology, and the distribution of the existing animals and plants proves that there was no ocean entitled to rank as the Atlantic during the Paleozoic and Mesozoic eras, and that its formation began at the end of the Cretaceous, *and was effected mainly after the widespread mountain-forming movements of the Oligocene.*

In 1936, under the title of *Recent developments in the geophysical study of oceanic basins*, I had the temerity to suggest, "that the sub-Atlantic lithosphere constitutes a vast area of *downwarped* Pre-Cambrian and Paleozoic geology, fully comparable in the complexity of its subsidiary stratigraphic, structural, and paleogeographic features to the *upwarped* Pre-Cambrian and Paleozoic geology of the surrounding continental areas . . . In the late Tertiary (and early Quaternary) there may still have been some subaerial remnants whose land areas were temporarily enlarged by the climatic events of the Pleistocene." Since making this statement, I still further suggest that there may have been profound, local, Quaternary movements in the basin itself; and that these movements may have affected ocean level, especially if there were coincident movements in the floor of the Pacific.

In a sense, geologists today may be classified as pro- or anti-Wegenerians. Most of the pro-Wegenerians are European, although we have a number in the United States and Canada. It is hardly necessary to remind you that the Wegener Hypothesis suggests that the Pacific was the one and original oceanic basin, and that the present pattern of the continents is like a picture puzzle, North and South

America having broken away from Europe and Africa at the close of the Paleozoic. Thus the Atlantic is supposed to have been growing bigger and bigger throughout the Mesozoic and Cenozoic eras, at the expense of the Pacific, while the great American continental rafts slowly but surely plowed their way southward and westward. During the last twenty years, the geophysical debate on this hypothesis has centered around such questions as: (1) The possible mechanism for continental drift. (2) The possibilities for determining the rate of the drift. Or, in other words, if the continents are drifting they may have drifted the distance required by the hypothesis. Up until ten years ago little or no positive data, other than a few soundings, existed on the condition of the suboceanic lithosphere. Thus the principal arguments put forward by the geologists in support of the Wegener Hypothesis were confined to: (1) The marginal patterns of the continents as exemplified in the outlines of the submerged continental margins. (2) The supposed lithological, structural, and stratigraphical similarities of the torn continental margins. When one doubting American geologist was asked why he proposed to restudy the Old Red Sandstone of the Scottish Highlands, he humorously replied: "To see if I can discover the tail of a new species of Devonian fish whose head I have recently collected from the coastal cliff of the Gaspé Peninsula." Even the fish is assumed to be moving westward at the time of its demise. With the possible exception of isostasy, and the postulate of the geosyncline, no hypothesis has so served to stimulate further and more varied geological and geophysical investigation, both applied and theoretical, as has Alfred Wegener's suggestion of drifting continents. In my own case, at least, I can affirm that the hypothesis has strongly influenced my motives in attempting to obtain, through geophysical means, original data on the structure of the submerged continental margins of the sub-Atlantic lithosphere. To sum up present opinion regarding the Wegener Hypothesis:

1. A number of structural geologists, especially those who are thoroughly familiar with Alpine tectonics, are in favor of continental drift.

2. An increasing number of geophysicists and astronomers find it an attractive working hypothesis, without perhaps sufficient interest in its origin or the reasons why it was formulated.

3. Nearly all paleogeographers, and most American structural geologists, are against the hypothesis, and this, in spite of the fact that it was originally proposed to mitigate, if not entirely overcome,

most of the serious difficulties imposed on the student of Paleozoic paleogeography by the earlier dictum of the permanency of relatively large oceanic areas.

4. The hypothesis, at least, attempts to solve an important dilemma; namely, it does away with the necessity of Paleozoic land bridges and yet allows for sufficient oceanic area at all times during the structural evolution of the earth.

This problem of the quantitative constancy of the hydrosphere has become of increasing importance in major geological problems during the past few years. It has not yet been definitely determined whether or not the hydrosphere has materially decreased or increased throughout geologic time. Undoubtedly a large amount of water has been temporarily removed from the hydrosphere as connate water and permanently as water of crystallization; on the other hand, an appreciable amount of juvenile water must have been added to the hydrosphere by volcanoes, both continental and submarine. During the past five years, the study of the submarine canyons which dissect the drowned margin of the continental shelves has led to the suggestion that the general ocean level may have been temporarily reduced, over a mile, during the Pleistocene. These submarine canyons were first called to the attention of geologists by J. W. Spencer in 1903. The recent revival of interest in submarine canyons is principally due to new data produced by the skillful geophysical methods of the U. S. Coast and Geodetic Survey, and the mapping and discussion of the data by F. P. Shepard. Shepard suggests that the canyons are entirely of subaerial origin, cut during the Pleistocene, when the ocean level was reduced approximately 3,000 to 6,000 feet by the temporary accumulation of ice on the continents. R. A. Daly, the exponent of a similar hypothesis in relation to the origin of coral reefs, will agree to the reduction of ocean level some 250 feet, but cites what he considers to be insurmountable geophysical difficulties in such a reduction of ocean level as demanded by Shepard. Daly and others have also attempted to explain the origin of the canyons by other means,[2] but no geologist believes that the canyons could be

[2] Daly suggests that the canyons have been eroded by the submarine scour of exceedingly muddy and super-saline waters, which he postulates occurred at the margins of the Pleistocene ocean. In a recent letter, E. B. Bailey suggests that submarine earthquakes might "help" Daly's hypothesis. H. H. Hess and Paul MacClintock agree with Shepard that the submarine canyons must be of subaerial origin, the result of the requisite reduction of sea level. They, however, in order to overcome what they consider to be the difficulties of a 20,000 to 50,000 foot ice sheet on the continents, suggest what is, apparently, a still more comprehensive astronomical, geodetic, and geophysical difficulty, namely, a relatively rapid and recent change in the ellipticity of the surface

explained by recent pronounced differential movements of the continental margin and ocean floor. Yet it is particularly interesting that the mouths of these submarine canyons dissect the boundary of one of the most pronounced topographic features of the submarine lithosphere, with the possible exception of the foredeep associated with island arcs.

The rise of the application of geophysical methods to the study of the suboceanic lithosphere really began some ten years ago, when F. A. Vening Meinesz first discovered the strip of highly negative gravity anomalies paralleling the East Indian arc and associated foredeep. On the U. S. Navy-Carnegie Expedition of 1928, and the U. S. Navy-Princeton Expedition of 1932, Meinesz discovered the western end of another negative strip. On the recent U. S. Navy-

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of the oceans, due to a sudden decrease in the rate of the rotation of the Earth, and the consequent drawing of the oceanic waters into the polar latitudes. From a letter on the very important question of submarine surveying and physiography, which Dr. D. W. Johnson allowed me to read to the Committee on Continental and Oceanic Structure at the Edinburgh meeting of the International Union of Geodesy and Geophysics, I quote as follows:

"The student of submarine topography, like the unhappy children of Israel, is forced to make bricks without straw. This is clearly apparent in current discussions of the long-debated problem of submarine canyons, where the investigator must formulate hypotheses without that adequate basis of facts which detailed maps of the ocean floor alone can give. The hypothesis that submarine canyons are normal river valleys, carved when the lands stood thousands of feet higher than now, involves consequences for the adjacent land areas which do not appear to be realized. The hypotheses which depend upon the subsurface flow of reaction currents of the type described by Ekman, of heavy currents of colder water, or of heavy currents of silty water, seem of doubtful validity because the potency of the cause appears insignificant when compared with the magnitude of the results accomplished. It is equally difficult to see how submarine landslides could effect the headward development of canyon-like depressions which appear to be long, narrow, and deep. As Professor Davis remarked a few years ago, the origin of submarine canyons remains an open question.

"Recently while studying the supposed meteorite scars of the Carolina coast I have had occasion to consider the effects of underground waters welling up in the form of so-called 'fountain springs,' and producing elongated depressions by a sort of headward migration up the coastal plain slope. It is known that the coastal plain deposits carry water under heavy pressure out under the sea, and that such water rises in artesian wells drilled on islands or sandbars several miles off the coast. I have wondered whether it could be possible that some pervious bed or beds of the coastal plain, at least in occasional places, carry water under pressure to the edge of the continental shelf. If deep submarine springs should develop there, would not such springs perforce migrate backward into the shelf deposits, leaving canyons the depth of which would depend upon the depth at which the upwelling waters escaped on the face of the continental scarp? It will be recalled that such impressive features as the deep and long "alcoves" eroded in the scarps of lava plateaus in the northwestern United States have been ascribed to just such headward migrating spring action. Submarine canyons cut in continental shelves at present submerged off rocky coasts may have been carved when parts of the shelf were above sea level and served to take in water which then migrated down the dip to the scarp face; or aquifers in the older rocks may connect under ground with overlying pervious formations of the blanketing shelf deposits.

"I mention this hypothesis of submarine canyon origin, not because it is now entitled to serious consideration (it occurred to me recently in the midst of other work, and I have not had time to test it adequately, or even to discover whether it has already appeared in the literature), but because it illustrates the difficulty of working without adequate facts."

Geophysical Union Expedition, which returned this January 15, Maurice Ewing, A. J. Hoskinson, and Harry Hess have proved that the negative strip parallels the West Indian Island Arc to its southern termination. Thus we can now say that a pronounced lineal concentration of the greatest known negative gravity anomalies appears to be a common and exceedingly important characteristic of what is suspected as the most profound type of deformation of the lithosphere, from the point of view of both relief and structure. It is also interesting to note that this statement is equally true for both the Atlantic and the Pacific, in spite of the fact that recent seismic evidence strongly suggests important widespread and deep-seated petrological and structural differences between these two great suboceanic areas of the lithosphere.[3]

The geophysical study of island arcs also appears to throw new light on the origin of geosynclines, or those great continental lineal troughs which are characterized by excessive thicknesses of folded and faulted shallow water sediments. It now appears that these great troughs, or furrows, such as the foredeeps, are formed quite independently of sedimentary load. In the case of island arcs, the parallel geanticline is of such small area that it contributes little or no sediment to the trough while it is being formed. On the other hand, where such furrows are developed marginal to, or within, continental areas, they may be filled with sediments as rapidly as they are depressed, any excess sediment being carried beyond the lineal loci of the depressed basement rocks. This evidence that major diastrophic movements of the lithosphere may be entirely independent of the shifting

[3] During the meeting of the Committee on Continental and Oceanic Structures at Edinburgh, this fall, Dr. Meinesz referred to the distribution of positive anomalies as follows: "Besides the narrow strip of negative anomalies in the East Indies, another systematic deviation of isostasy has been found: The deeper basins of the archipelago all show rather strong positive anomalies over the whole fields of the basins. These fields of positive anomalies are also found in other parts of the world in (possible) geosynclinal areas; they have been found over the basins of the West Indies (Gulf of Mexico, Sea between Cuba and Mexico, and in a few stations in the Caribbean), in the deeper basins of the Mediterranean (e.g., Tyrrhenian Sea and the northwestern part of the Mediterranean). Most of these basins are considered by the leading geologists to have sunk away in recent times; viz., since the Tertiary or in the last half of the Tertiary. A tentative explanation may perhaps here be suggested. It is difficult to explain these fields of positive anomalies by an increase of density of the crust and a sinking because of a subsequent readjustment of isostasy for in that case it cannot be understood that these basins are still so far out of isostatic equilibrium. The hypothesis of convection-currents in the substratum seems to promise more." [It is possible that magnetic studies in these regions of positive anomalies might give additional data on the convection-currents hypothesis.—R.M.F.] Dr. Meinesz closed his discussion with the following statement: "As many of the features of the gravity anomalies are clearly related to the surface features of the crust, topographical and geological, it seems advisable to study them in close collaboration with the geologists and geomorphologists, who have an intimate knowledge of these subjects."

load of sediments is still further being confirmed by the greatly increased number of soundings which have been obtained by geophysical methods in both the Atlantic and the Pacific. Whereas, only a few years ago, the bottom of the Pacific was supposed to be relatively flat, we now know, thanks to the excellent work of the U. S. Navy, that it has high relief, probably of much the same type as that of mountainous continental regions. In his recent interpretation of the bathymetric data obtained on the Snellius Expedition, 1935, P. H. Keunen calls attention to the probable existence of submarine troughs, block-faulted mountains, and fault scarps on an even greater order of magnitude, and more sharply defined both topographically and structurally, than exist on the continents. To quote:

> The theoretical importance of these scarps appears to be considerable. As erosion is practically non-existent on the sea-bottom, and as sedimentation is comparatively slow, it is in itself not surprising to find that a fault scarp, once it is produced, remains standing as a bold cliff, in some cases as much as 3,000 feet high, a feature far more striking than the most pronounced subaerial fault scarps known. The chief interest of these scarps is that they prove the rigidity of the bottom where they occur and that they demonstrate the ability of a fault to reach gigantic proportions without the aid of erosional obliteration of the load of the thrown-up limb.

It must be further appreciated that these submarine structures are formed under 5,000 to 6,000 meters of sea water, the resulting hydrostatic pressure corresponding to a depth beneath the surface of the continental lithosphere of approximately 5,000 to 6,000 feet of solid rock. Thus the suboceanic lithosphere must be quite rigid, not only at the surface but also at considerable depth beneath the surface. Finally, perhaps most important of all, the varied types of evidence just cited necessarily intimate profound diastrophism in the suboceanic lithosphere, over great areas, entirely independent of the transference of load through erosion and deposition; in other words, that the fundamental causes of diastrophism may be deep-seated and largely independent of surface processes.

In closing this greatly condensed history of the geophysical-geological exploration of oceanic basins, I feel it is necessary to emphasize two particularly important submarine geophysical-geological techniques which were started several years ago, and which, within the past few months, have not only produced very important data, but have clearly demonstrated their great potential value. Not only students of sedimentation, but all students of earth science are deeply indebted to C. S. Piggot for the remarkable instrument which he has

developed for procuring 10–14 foot cores of oceanic sediments. Time does not permit, nor should I wish to attempt to anticipate the important data which will result from the study of these and future cores, but it is important to note that Piggot has been the first man to improve fundamentally the method of sampling deep sea sediments since the historic voyage of the *Challenger*. This is no mean accomplishment in a pioneer field. To supplement the data derived from the samples of the upper few feet of suboceanic sediments, the American Geophysical Union, through its special Committee, promoted a project for the seismic study of the submerged portion of the continental shelf. Under the able leadership of Maurice Ewing and N. H. Heck, and with the indispensable cooperation of the U. S. Coast and Geodetic Survey, the Woods Hole Oceanographic Institution, and the Geological Society of America, by means of this important new technique, a submarine seismic profile was run from the wedge-point of the Cretaceous-Tertiary overlap to the edge of the continental shelf. According to this single profile, the wedge of Cretaceous-Cenozoic sediments thickens rapidly until, at the continental margin, it is approximately two miles thick.[4] Thus the pre-Cretaceous erosion surface exposed to view in the Piedmont region is at least a mile below the bottom of the bathyal slope at the continental margin. Every effort will be made within the next year or two to discover if this important structural feature continues beyond the edge of the continental platform and eastward under the Atlantic basin. Present indications are that the topographic limit of the Atlantic continental margin may be of no particular structural significance. This prophesy is apparently still further strengthened by the work of Gutenberg and Richter who, after making a careful study of the Atlantic seismic reflections, produced by earthquakes, have come to the conclusion that the Atlantic basin is everywhere underlain by sial, instead of sima; or, in other words, that from 15 to 20 kilometers of continental rocks form the basement of the entire sub-Atlantic lithosphere. Thus the new data suggest not only that there may have been no Atlantic basin in existence during an appreciable portion of the earlier history of the earth, but, more interesting still, that the present Atlantic basin may be due to the downwarp, in post-Paleozoic time, of a vast and now vanished continental area. Such a lost continent could not be a "lost Atlantis" according to the popular conception of the term, but, if true, it might be called a "lost Atlantica" in the structural and

[4] As the wedge thickens oceanwards it may include lower Mesozoic marine sediments.

paleogeographic sense. At any rate, I believe that, by geophysical methods, we shall be able, before long, to procure sufficient data concerning the basement rocks of the Atlantic to be able to prove, among other things, whether North and South America ever were connected with the present trans-Atlantic continents. While discussing this possibility with Harold Jeffreys last fall at Edinburgh, he said: "I hope that the present sub-Atlantic area was not a continent during the Paleozoic because if it was, I certainly would not know where to put the Atlantic Ocean during the Paleozoic Era." I agreed that would be a tremendous amount of water on anybody's mind, even after making due allowances for essential geosynclinal, epeiric, and epicontinental seas. But, as I have previously mentioned, we may already be faced with considerable difficulty in accounting for the origin of the submarine canyons in the continental shelves. In 1909 Daly demanded a reduction of ocean level of some 300 feet to account for the origin of atolls. Today Shepard demands the reduction of ocean level over a mile to account for the subaerial erosion of the now submarine canyons. A short time hence, we may be wrestling with the problem of where to put the Atlantic Ocean during the Paleozoic. I, therefore, suggest that, until we have more data on the topography and structure of the suboceanic lithosphere, we are not in a particularly strong position to check any major hypothesis which attempts to explain the pattern of the face of the earth. On the other hand, we already have sufficient data which strongly suggest theories other than those already proposed; I refer particularly to the data on the pronounced relief of relatively large areas of the bottoms of the oceans. In the first place, this pronounced relief is not particularly synonymous with the phrase, "ocean basin." We are still apt to think of a basin as a relatively circular depression with a relatively concave, smooth surface. I do not wish to emphasize this conception further than to point out that, in terms of smooth surfaces, a wide shallow basin will accommodate the same amount of water as a smaller but deeper basin. Also, provided the basin remains the same size, its liquid capacity may be increased or decreased by the deformation of its relatively smooth surface. Thus depressions such as the foredeeps of island arcs and fault valleys or grabens, such as the Bartlett Deep, which are developed below the mean basin level, tend to reduce ocean level; while, on the other hand, great positive areas, such as the somewhat misnamed Atlantic Ridge, tend to raise the ocean level. Thus, without necessarily changing the general shape of the basin, the development of many but minor inequalities in its

surface will alter the liquid capacity; and the chances will always be strongly against the possibility that the elevations and depressions will cancel each other, especially if they are not subject to isostatic compensation. At the present time, we do not have sufficient topographic data to compute the relation of relief of basin surface to basin capacity. Also, we have not sufficient data concerning the structure of the suboceanic lithosphere to determine the space-time relationships of the depressions and elevations. We do, however, have seismic evidence as to areas in which deformation is active at the present time. For several reasons, it seems wise to plan our geophysical-geological surveys from the continental margins into the oceanic basins for, in this manner, we shall be able to determine the continuity or discontinuity of structures whose space and time relationships *are* known. If, for the present, the theory of drifting continents may be considered as a valuable working hypothesis, it is primarily because it serves to stimulate the exploration of oceanic basins, and thus helps to produce new and badly needed data on that great "terra incognita" of a major portion of the crust of the earth, let that data lead us where it may. Finally, until these data are available, we can not even be sure that the continents are fair geological samples of the entire lithosphere.

SUMMARY

1. The attempt has been made to review the growth of ideas, theories, and hypotheses on continental and oceanic structure, especially in relation to their effect on future trends in geophysical-geological research.

2. From the geological point of view, the epitome of the problem is paleogeography, especially the paleogeography of the pre-Mesozoic history of the earth.

3. Emphasis has been placed on the lack of physiographic and structural data on the suboceanic lithosphere, and the importance of acquiring these data.

4. It has been suggested that further data on the topography and structure of the suboceanic lithosphere will throw important light on such major questions as isostasy, geosynclines, and continental drift.

5. Available data on the suboceanic lithosphere suggest that diastrophism, or the major deformation processes, is relatively independent of transference of surficial load, such as takes place under the conditions of erosion and deposition.

6. Fortunately, geophysical techniques are already, or soon will

be, available for making a geophysical survey of ocean basins. These techniques, to date, include exact positions and sounding, and determination of gravity and seismic methods, all equivalent in accuracy to those now used on the continents. Further, the techniques are sufficiently varied so that they can be used to support or check each other.

7. Since the oceans are international territory, they are not the particular business of any nation, and, though the freedom of the seas may be open to debate, the ocean bottom is unclaimed territory. Last fall, the International Union of Geodesy and Geophysics, at its Edinburgh meeting, created a Commission on Continental and Oceanic Structure. This Commission is approved and supported by twenty-four nations, and it is hoped and planned that it will help serve to promote effective international cooperation in the exploration of the suboceanic lithosphere.

8. The ultimate progress of submarine geophysical-geological surveying depends, however, first, on the methods to be employed or plan of attack, and, second, on the increasing use of important contributing agencies. While a certain amount of money is, of course, a necessary part of each project, such grants can be greatly reduced by the use of existing agencies. Further, in most cases, the grants will be useless without such important material contributions as submarines, cable ships, the specially equipped vessels of marine biological laboratories, and last, but not least, the trained personnel to operate these various types of vessels. So far, we have not found that geophysicists or geologists are particularly good sailors!

In conclusion, I wish to express the thanks of the American Committee of the International Geodetic and Geophysical Union to the United States Navy, the United States Coast and Geodetic Survey, the Woods Hole Oceanographic Institution, the American Bell Telephone Laboratories, the American Philosophical Society, the British Admiralty, the Geophysical Institutes of Norway and Holland, and the Geological Society of America for their most generous and indispensable aid in the exploration of "no man's land." But, as Dr. Bowie has so frankly put it, present thanks carry the intimation of a desire for future favors. Fortunately, even geophysicists and geologists are human, and particularly the new amphibious variety, who have braved the ocean deep, and who, in fear of being wrecked upon a storm of hypotheses, are crying out for more and more help in their factual surveys.

BOTANY.—Phacelia mustelina, *a new plant from Death Valley, California.*[1] FREDERICK V. COVILLE, Bureau of Plant Industry.

Eleven species of the genus *Phacelia*, family Hydrophyllaceae, are known from Death Valley. One of them, *Phacelia perityloides*, is a round-leaved, white-flowered perennial. All the others are annuals that have blue, violet, purple, or lavender flowers. In years of good rainfall several of these species are abundant and characteristic plants of the desert landscape, and a few of them are conspicuous for their beauty. Their blossoms occur in a one-sided cluster known as a scorpioid raceme, or scorpioid cyme, which unrolls, as the flowers open, from a tight, flat spiral. From this characteristic of their inflorescence, the species of *Phacelia* are known as curlybloom.

The present paper deals with an apparently new species of this genus, discovered in Death Valley by M. French Gilman.

Phacelia mustelina Coville, sp. nov.

Planta annua, *Phaceliae rotundifoliae* affinis, sed foliis ovatis vel oblongis et corolla violacea, quam calyce fere duplo longiore, corollae tubo calycem a circiter duplo longitudine loborum corollae superante; *Phaceliae pulchellae* etiam affinis, sed caulibus glanduloso-pilosis, corollae latitudine circiter 4–5 mm. *Phaceliae rotundifoliae* folia orbicularia vel reniformia sunt, et corolla alba, tubo calycem vix superante; *Phaceliae pulchellae* caules glanduloso-puberulenti sunt, et corollae latitudo 8–10 mm.

Plant annual, 3 to 10 cm high, branching; stems, as well as the petioles, leaf blades, peduncles, pedicels, and calyx lobes, pilose with weak hairs, many of them gland-tipped; leaf blades up to 2.5 cm long, ovate to oblong, mostly cordate at the base, coarsely and shallowly dentate with as many as 5 large teeth on each side and often with much smaller teeth in the sinuses between the large teeth, the lower leaves with petioles longer than the blades, sometimes twice as long; inflorescence consisting of terminal several-flowered scorpioid bractless cymes, on peduncles 1.5 cm or less in length, the lowest pedicels 5 mm long or less; calyx lobes 3.5 to 5.5 mm long, narrowly oblanceolate to narrowly oblanceolate-spatulate, obtuse; corolla about 4 to 5 mm across when expanded, 6 to 9 mm long, violet, nearly twice as long as the calyx, the corolla tube usually exceeding the calyx by about twice the length of the corolla lobes, and about 2 to 3.5 mm in diameter at the base of the lobes, pilose above with long weak hairs, an occasional hair gland-tipped, the lower part of the corolla tube glabrous, the lobes rounded, broader than long, about 2 mm wide and 1.5 mm in length, the corolla appendages attached by one margin to the corolla tube, linear, narrowed above and without a free apex; stamens 5, shorter than the corolla tube, the filaments unequal, very sparingly hairy toward base but usually appearing hairless even under a lens; ovary and immature capsule sparingly hairy, ovules 40 in the ovary examined, the style longer than the calyx, sparingly hairy below, bifid at the apex to the depth of about 1 mm; seeds immature 0.5 to 0.8 mm long, pitted.

[1] Received January 29, 1937. This is the last paper written by Dr. Coville.

Type specimen in the United States National Herbarium, no. 1,630,905, collected June 23, 1935, by M. French Gilman, no. 1810, in Death Valley, California, at the head of Titus Canyon, Grapevine Mountains, tightly wedged in the crevices of a ledge of rhyolite rock, at an elevation above 6,000 feet.

Collected also on rock ledges at similar elevations in a branch of Wildrose Canyon, June 13, 1935 (Gilman 1706), and in Wood Canyon, June 18, 1935 (Gilman 1750), both on the west slope of the Panamint Mountains, which border Death Valley on the west.

Probably the nearest relative of *Phacelia mustelina* is *P. gooddingii* Brand, 1913, a species which appears to be the same as *P. pulchella* A. Gray, 1875. Brand, in his account of the genus *Phacelia* in the Pflanzenreich (Heft 59, 1913), distinguishes *gooddingii* from *pulchella* by its glabrous filaments and its approximately 25 ovules on each placenta. He describes *pulchella* as having sparsely pilose filaments and 7 to 10 ovules to each placenta.[2] A careful examination of the original collection on which *Phacelia pulchella* was based, C. C. Parry no. 182,[3] and of the original collection from which *P. gooddingii* was described, Goodding no. 2307, shows that in both specimens the filaments are sparingly pilose toward the base, and the ovules are about 50 to 60 per capsule. Both type specimens are branched from the base, the branches ascending and glandular-puberulent. In both specimens the calyx, at flowering time, is about 5 mm long, and the corolla twice as long or sometimes more. I can find no reason for separating *gooddingii* from *pulchella*. The type specimen of *pulchella* came from the vicinity of St. George, southwestern Utah, where it grew on "gypseous clay knolls." The type of *gooddingii* came from Las Vegas, southeastern Nevada, little more than a hundred miles from St. George and in the same climatic zone, and was recorded by its collector, Leslie N. Goodding, as growing on "gumbo flats."

Phacelia mustelina differs from *P. pulchella* in its glandular-pilose stems, the hairs weak and the longer ones half a millimeter or even a millimeter in length; its non-glandular hairs (mixed with gland-tipped hairs) on the leaf blades weak and often reaching a length of 0.7 mm or more; and its corolla about 4 to 5 mm across, when the lobes are expanded. In *pulchella* the stems are glandular-puberulent, the gland-tipped hairs stout, and probably not more than a tenth of a millimeter in length; the non-glandular hairs (mixed with gland-tipped hairs) on the leaf blades are stout and less than half a millimeter in length; and the corolla is about 8 to 10 mm across when the lobes are expanded. In all our specimens of *mustelina* the larger leaves are cordate at the base, a characteristic seldom found in *pulchella*. Mature seeds of *P. mustelina* are not available for comparison with those of *pulchella*.

Among the phacelias of Death Valley itself the species most closely related

[2] Pflanzenreich 59: 105, 116, 120. 1913.

[3] See A. GRAY, Proc. Amer. Acad. Sci. 10: 326. 1875. Also C. C. PARRY, Amer. Nat. 9: 16. 1875.

to *mustelina* is *Phacelia rotundifolia* Torr. Our specimens of *rotundifolia* from the Death Valley region were collected at elevations below 5,000 feet, the lowest at 900 feet. Besides this differences in altitudinal range and the differences between *mustelina* and *rotundifolia* cited in the Latin diagnosis, Mr. Gilman writes that the odor of the herbage of the new species is different from that of *rotundifolia* and is the "odor of an angry or scared weasel," a characteristic indicated in the name *mustelina*.

BOTANY.—*New species and nomenclatorial changes in eastern Asiatic Myrsinaceae.*[1] EGBERT H. WALKER, U. S. National Museum. (Communicated by ROLAND W. BROWN.)

This is the fourth paper[2] the writer has published on the Myrsinaceae of China and Japan preliminary to a critical revision of this group. The new species and nomenclatorial changes are here published because of unavoidable delay in the appearance of the revision.

Ardisia (Subg. **Akosmos** Mez) **brunnescens** Walker, sp. nov. Fig. 1

Frutex 3 m altus undique glaber; folia subtus brunnescentia glandulis marginalibus non donata, nervis lateralibus 10–15-jugis, subtus elevatis, venulis elevatis reticulatis, nervo marginali non prominulo vel nullo; inflorescentiae in ramulis glabris lateralibus specialibus subterminales, paniculato-cymosae vel duplicato-umbellatae, ramulis gracilibus, pedicellis gracilibus nonnihil clavatis; flores 4 mm longae; sepala ovata, obtusa, per anthesim non valde dextrorse imbricata, non-numquam obscure fusco-lepidota; fructus atro-rubescens, nonnihil obscure punctatus.

Type in the herbarium of the New York Botanical Garden, collected by H. B. Morse at Lungchow, Kwangsi, no. 708, distributed by A. Henry. An additional specimen is Wang no. 485, collected in Yun Fou District, West River region, Kwangtung, distributed by Sun Yatsen University.

This species seems to resemble most closely *A. viburnifolia* Pitard in Lecomte's Fl. Gen. Indo-Chine **3**: 821. 1930. In the original description of that species no collector's number is cited, but a specimen in the New York Botanical Garden, Poilane no. 11914 from the same locality, apparently belongs to Pitard's species. It differs in having fewer prominent lateral nerves and flowers about half as large as those of *A. brunnescens*.

Ardisia (Subg. **Crispardisia** Mez) **filiformis** Walker, sp. nov. Fig. 2

Frutex 1 m altus, ramulis pergracilibus glabris; folia membranacea, 12–19

[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 27, 1937.

[2] *Four new species of Myrsinaceae from China.* This JOURNAL. **21**: 477–480, figs. 1–4. 1931.

Embelia scandens (Lour.) *Mez and its eastern Asiatic allies.* Lingnan Sci. Jour. **10**: 475–480. 1931.

Maesa hirsuta (*Myrsinaceae*), *a new shrub from Kweichow, China.* Papers Michigan Acad. Sci. **20**: 231–232, pl. 50. 1935.

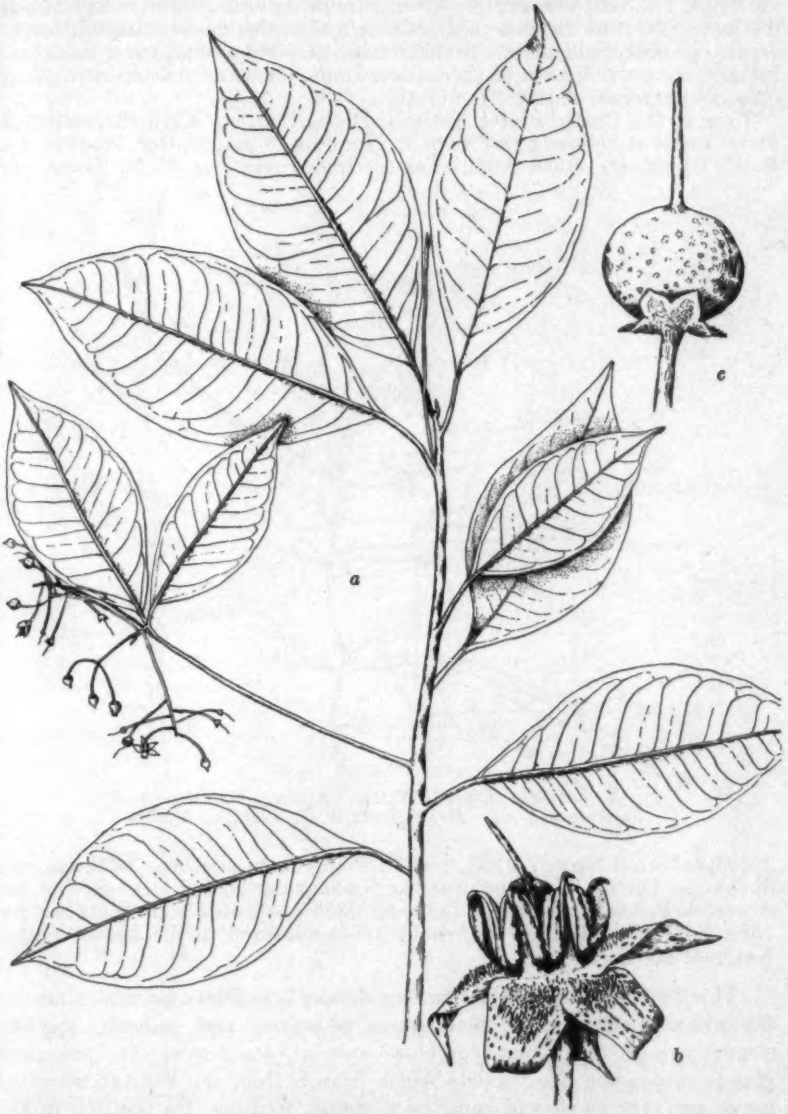

Fig. 1.—*Ardisia brunnescens* Walker, sp. nov. *a*, Branchlet with inflorescence, ½ nat. size; *b*, flower, ×5; *c*, fruit, ×5. Drawn from type specimen *Morse* no. 708.

cm longa, 1–2.5 cm lata, glabra, subtus paulum lepidota, nervis marginalibus distinctis, nervulis ramosis in glandulas marginales desinentibus; inflorescentiae glabrae, paniculatae, ramulis valde gracilibus; sepala non valde imbricata, minute punctata; antherae dorso non punctatae; fructus circa 6 mm longus, rubescens, distincte punctatus.

Type in the United States National Herbarium, no. 1,273,493, collected under forest at Seh-feng Dar Shan, S. Nanning, Kwangsi, Oct. 19, 1928, by R. C. Ching, no. 8000. Additional specimens seen are *W. T. Tsang*, no.

Fig. 2.—*Ardisia filiformis* Walker, sp. nov. Branchlet with inflorescence ×½. Drawn from *W. T. Tsang* no. 22393.

22393, collected May 27, 1933, near Iu Shan village, southeast of Shang-sze, Shang-sze district, Kwangsi near the Kwangtung border, deposited in the Arnold Arboretum; and *W. T. Tsang* no. 22567, collected in the same locality June 26, 1933, deposited in Arnold Arboretum and in the United States National Herbarium.

This species is distinct in its very slender branchlets, its paniculate inflorescences with almost filamentous peduncles and pedicels, and its slenderly lanceolate, long-acuminate membranous leaves. The marginal glands subtending the veinlets which branch from the distinct marginal nerve are very small and sometimes almost wanting. Its position in the subgenus *Crispardisia* is thus uncertain.

Embelia henryi Walker, sp. nov. Fig. 3

Frutex scandens, ramulis novellis puberulis glabratis; folia coriacea, 20–30

mm longa, 8–10 mm lata, serrulata, subtus nigro-punctata, nervis lateralibus numerosis, obscuris, subtilibus; flores 5–7, 5-meri, subcorymbosi, pedunculo 4 mm longo, e basi subsquamosa vel subnuda oriundo, pedicellis 3–4 mm longis; fructus globosus, 4 mm longus, atro-ruber, nigor-punctatus.

Type in the herbarium of the Arnold Arboretum, collected at Mengtze, Yunnan, by A. Henry, no. 10913; duplicate in the Herbarium of the New York Botanical Garden.

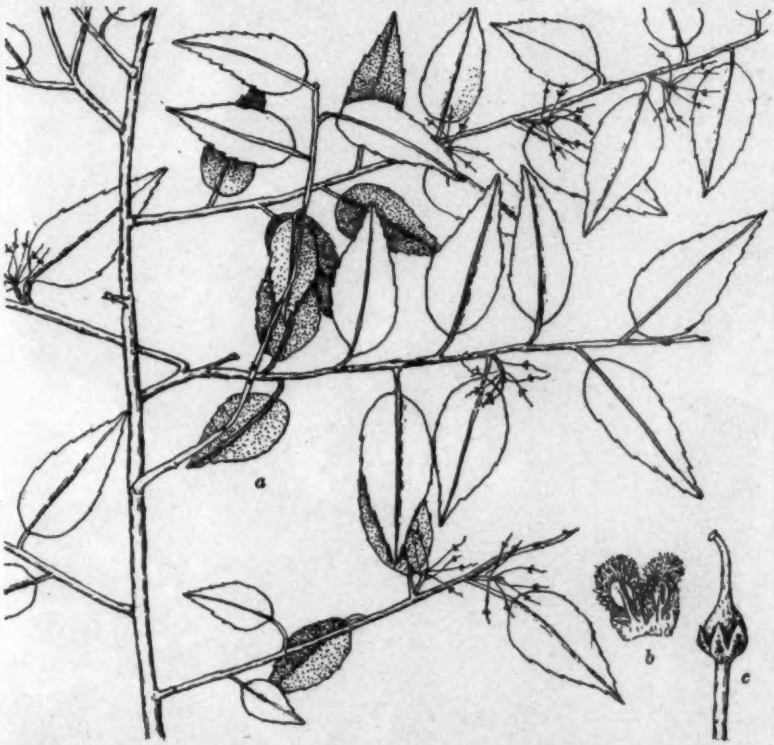

Fig. 3.—*Embelia henryi* Walker, sp. nov. *a*, Branchlet with inflorescences, natural size; *b*, portion of corolla of ♀ flower showing attached stamens, ×8; *c*, pistil, ×8.

Maesa insignis Chun, Sunyatsenia **2**: 81, pl. 20. 1934

Maesa hirsuta Walker, Papers Michigan Acad. Sci. **20**: 232, pl. 50. 1935.

The description of Chun's species appeared in print while that of *M. hirsuta* Walker was in process of publication and the manuscript could not be recalled. Subsequently a type collection of Chun's species was examined and found to differ significantly only in length of petioles. However, such a difference is not a valid character for separating these two species.

(For explanation of Fig. 4, see bottom of opposite page.)

Maesa permollis Kurz, Jour. Asiat. Soc. Bengal. 40[2]: 66. 1871

Stout climbing shrub, 2 to 3 m high, the branches rather few somewhat thickened or the ultimate rather slender, densely pubescent with rufous setose hairs almost throughout; leaves petiolate (3–25 mm), the blade thick-membranous, about 25 cm long, 12 cm wide, ranging from 12 to 30 cm long, 4 to 18 cm wide, elliptic or oblong to broadly obovate, rounded or obtuse at base, obtuse to acute or acuminate at apex, distinctly sinuate or serrate-dentate with callose teeth, green and glabrous or nearly so above, brownish and densely rufous pilose or hirsute beneath especially on the nerves, the midrib prominent, the lateral veins terminating in the teeth; inflorescence short, subglomerate or racemose or subpaniculate, shorter than petiole or up to 4 cm long, rather many-flowered, densely hirsute; flowers about 3 mm long, on short pedicels scarcely 1 mm long, white, the bracts minute, about equaling the pedicels; sepals equaling the pedicels, united into a tube almost as long as the limb, ovate, acute, densely hirsute or pilose, the margin narrowly scarious; corolla tubular campanulate, glabrous, the tube about 2 mm long, lightly lined or smooth, the lobes ovate, narrowly rounded, more or less spreading; stamens included, attached within the tube, the filaments short, the anthers about equal to the filaments, broadly elliptical; pistil with short thick style and indistinctly lobed stigma; fruit about 4 mm long, ovoid, acute or apiculate at apex, reddish, densely hirsute.

Distribution.—Southern Asia from Burma to Yunnan and Kweichow.

Specimens examined in various American and British herbaria:—Kweichow: *Y. Tsiang* 4622, 4768. Yunnan: *Forrest* 29394; *Henry* 9649, 9649A, 9649B, 11707, 11707A, 11707B, 11707C, 11707D; *Rock* 2580.

Maesa permollis var. **effusa** Walker, var. nov. Fig. 4

Frutex 3–8 m altus, e forma typica inflorescentibus valde paniculatis ad 9 cm longis differens.

Type in the herbarium of the Royal Botanic Gardens, Kew, England, collected by G. Forrest, No. 12143, in Yunnan; duplicate in the herbarium of the Royal Botanic Garden, Edinburgh. An additional collection is *Forrest* 13637, collected in the "open Jungle in the Taping valley, Upper Burma, . . . alt. 2000 ft, April 1917."

ZOOLOGY.—*A note on the members of the nematode genus* Trichostrongylus *occurring in rodents and lagomorphs, with descriptions of two new species.*[1]

GERARD DIKMANS, U. S. Bureau of Animal Industry. (Communicated by EMMETT W. PRICE.)

The genus *Trichostrongylus* was established by Looss (1905) with *Trichostrongylus retortaeformis* (Zeder, 1800) Looss, 1905, as type species. At the present time the genus contains a large number of species of which the following have been reported from rodents and lagomorphs:

[1] Received March 2, 1937.

Fig. 4.—*Maesa permollis* var. *effusa* Walker, var. nov. Type specimen, slightly less than half natural size.

1. *Trichostrongylus fiberius* Barker, 1915, from the American muskrat, *Ondatra zibethica* (=*Fiber zibethicus*), (?) Nebraska.

2. *Trichostrongylus calcaratus* Ransom, 1911, from cottontail rabbit, *Sylvilagus floridanus mallurus*, Bowie, Maryland.

3. *Trichostrongylus retortaeformis* (Zeder, 1800) Looss, 1905, from the domestic rabbit, *Oryctolagus cuniculi*, and European hare, *Lepus europeaus*, Europe.

4. *Trichostrongylus pigmentatus* (von Linstow, 1904) Hall, 1916, from *Lepus nigricollis*, Ceylon.

5. *Trichostrongylus affinis* Graybill, 1924, from wild rabbits, Princeton, New Jersey.

6. *Trichostrongylus delicatus* Hall, 1916, from the squirrel, *Sciurus aberti mimus*, Colorado.

7. *Trichostrongylus colubriformis* (Giles, 1892) Ransom, 1911, from hares and rabbits in U.S.S.R. and from *Sylvilagus nuttallii pinetis* and *Lepus* sp. in the United States.

As noted by Hall (1916), Barker's description of *Trichostrongylus fiberius* is very unsatisfactory. Neither the nature of the bursal rays nor that of the spicules can be determined from his figures and descriptions. During the course of the present investigation, trichostrongyles collected from muskrats originating in New Jersey and Iowa have been identified as *Trichostrongylus calcaratus* Ransom, 1911.

Trichostrongylus retortaeformis (Zeder, 1800) Looss, 1905, has been reported as a parasite of rabbits and hares from Europe, but to date there is no record of its occurrence in these animals in the United States. The one specimen labeled *Trichostrongylus retortaeformis* found in the Helminthological Collection of the U. S. National Museum proved on examination to be *Trichostrongylus calcaratus*.

An examination of rabbit parasites which had been entered in the Helminthological Collection of the Bureau of Animal Industry showed that a bottle labeled *Nematodirus* sp. from *Sylvilagus nuttallii pinetis* collected at Howbert, Colorado, contained two kinds of nematodes, one of which on examination proved to be *Trichostrongylus colubriformis;* this nematode was found to have been collected also from *Lepus* sp. in Nebraska. The determination of these latter specimens was made by Dr. E. W. Price of the Zoological Division. They are listed in the collection under Nos. 28165 and 28181. We have, therefore, three records of the occurrence of *T. colubriformis* as a parasite of the Leporidae in the United States. These records are from Colorado and Nebraska.

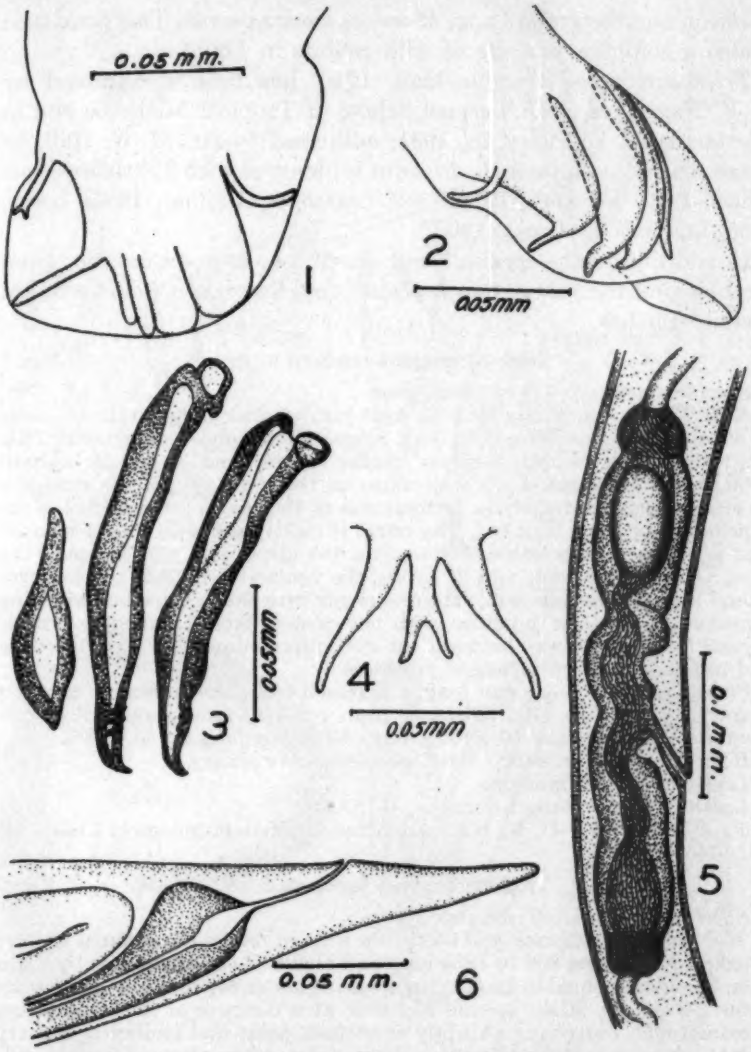

Fig. 1.—*Trichostrongylus ransomi*, n. sp. 1, bursa, right lateral view; 2, bursa, left lateral view; 3, spicules and gubernaculum; 4, dorsal rays of bursa; 5, muscular portion of ovejectors; 6, terminal portion of female.

Trichostrongylus calcaratus was reported by Ransom from *Sylvilagus mallurus* from Bowie, Maryland. During the present investigation these nematodes have been found also in the muskrat, *Ondatra*

zibethica, and the ground hog, *Marmota monax monax*. This nematode is also a common parasite of wild rabbits in Louisiana.

Trichostrongylus delicatus Hall, 1916, has been reexamined by H. F. Nagaty of the Liverpool School of Tropical Medicine and in a letter dated February 28, 1931, addressed to Dr. M. C. Hall, he states that in his opinion *T. delicatus* is identical with *T. colubriformis* (Giles, 1892) Ransom, 1911. (=*T. instabilis* (Railliet, 1893) Looss, 1905, and *subtilis* Looss, 1905.)

In addition to the species listed above, two new species, one from a rabbit and the other from a prairie dog, have been found and are described below.

Trichostrongylus ransomi n. sp. Fig. 1

Specific diagnosis.—Trichostrongylus:

Male 2.25 to 3 mm long by 100μ wide just anterior to bursa; head about 8μ wide. Esophagus 500 to 600μ long. Spicules equal and similar 130 to 140μ long; distal part of each recurved rather sharply and ending in a sharp point; there are three short projections on the inner side of the spicule a short distance in front of the termination of the spicule, which give it the appearance of being serrated. The bursa is tightly rolled in such a manner that it is almost impossible to determine the disposition and course of the rays. As in *T. calcaratus* and *T. affinis*, the ventro-lateral and the externo-lateral rays are the heaviest; externo-dorsals with slender tips but widening considerably at their juncture with the postero-lateral and dorsal rays; dorsal ray lying midway between the two externo-dorsals bifurcating once and terminating in two straight processes.

Female from 3 to 3.5 mm long. Combined length of muscular portions of ovejectors 375 to 440μ. Distance from vulva to anus about 450μ; that from anus to tip of tail 50 to 60μ. Eggs 60 to 70μ long by 30 to 36μ wide.

Host.—Rabbit (probably *Sylvilagus floridanus alacer*).

Location.—Small intestine.

Locality.—Jeanerette, Louisiana, U. S. A.

Type specimens.—U. S. National Museum Helminthological Collection no. 30462.

Trichostrongylus texianus n. sp. Fig. 2

Specific diagnosis.—Trichostrongylus:

Male 2.8 to 3 mm long and 65 to 70μ wide in region of proximal ends of spicules. Esophagus 800 to 825μ long and about 30μ wide near its termination. Spicules unequal in length; right spicule about 85μ long and left spicule about 100μ long. Right spicule 25μ wide at a distance of about 65μ from proximal end, narrowing abruptly from that point and ending in a sharp point; left spicule also ending in a sharp point; when viewed from the side both spicules present frontal projections, the one on right spicule located about 20 to 22μ from distal end, the one on left spicule about 30μ from distal end, both spicules presenting bluntly pointed branches originating near

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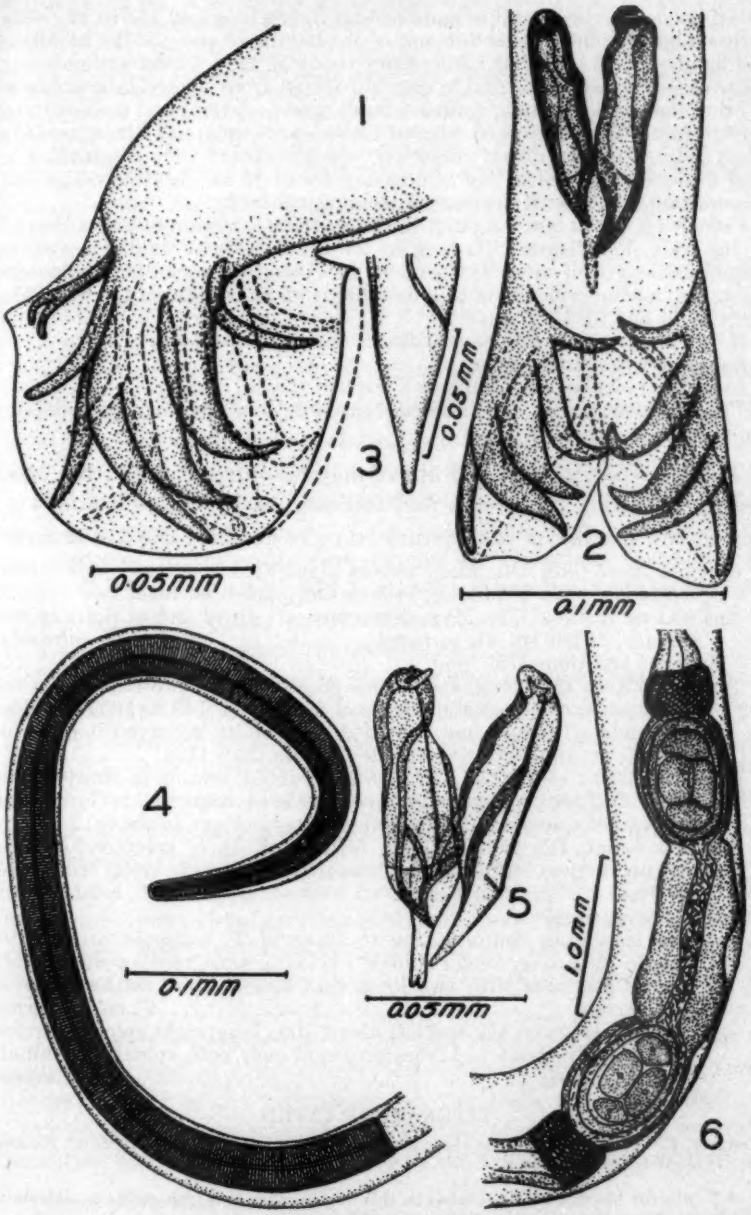
Fig. 2.—*Trichostrongylus texanus*, n. sp. 1, bursa, lateral view; 2, terminal portion of male, ventral view; 3, tail of female; 4, anterior portion of body; 5, spicules and gubernaculum; 6, muscular portion of ovejectors.



(For explanation of Fig. 2, see bottom of opposite page.)

dorsal border. Gubernaculum paddle-shaped, 55μ long and 15μ to 17μ wide, with a slight indentation in the end of the handle of the paddle; handle of paddle about 20μ long and indentation about 5μ long. Bursa symmetrical; ventro-ventral ray small and widely separated from ventro-lateral ray as in other members of genus; ventro-lateral, externo-lateral and medio-lateral rays running parallel toward edge of bursa; postero-lateral diverging from medio-lateral in the dorsal direction; externo-dorsal rays originating at base of dorsal ray; dorsal ray bifurcating about 12 to 15μ from distal end, the unbranched tips of bifurcation bending ventrally.

Female 4.8 to 5.2 mm long and 85 to 90μ wide in region of vulva; head 7 to 10μ wide. Esophagus 850μ long by 25 to 30μ wide at its distal portion. Combined length of muscular portions of ovejectors, including sphincters, 350μ. Vulva 850μ from end of tail; distance from anus to tip of tail 60 to 65μ. Eggs 70 to 80μ by 45 to 50μ.

Host.—Prairie dog, *Cynomys ludovicianus arizonensis.*

Location.—Small intestine.

Localities.—Nolan and Runnels Counties, Texas, U.S.A.

Type specimens.—U. S. National Museum Helminthological Collection no. 30463.

The two species described above may be differentiated from other species occurring in rodents and lagomorphs by the following key:

KEY TO THE SPECIES OF TRICHOSTRONGYLUS IN RODENTS AND LAGOMORPHS[2]

1. Spicules more than 550μ long; viscera pigmented black . . *T. pigmentatus*
   Spicules less than 500μ long; viscera not pigmented black 2
2. Spicules more than 175μ long, asymmetrical; distal end of right spicule smooth, of left spicule serrated . . . . . *T. calcaratus*
   Spicules less than 175μ long 3
3. Spicules 130 to 155μ long, distal ends provided with two blunt recurved hooks; distance from anus to tip of female tail 140 to 165μ *T. affinis*
   Distal ends of spicules not provided with blunt, recurved hooks; distance from anus to tip of female tail less than 140μ 4
4. Spicules 130 to 140μ long, distal ends recurved, ending in sharp points and with three projections on inner side of each spicule . . . . *T. ransomi*
   Distal end of spicules not provided with projections as above 5
5. Spicules equal, 135 to 145μ long, terminal hook of spicules long and sharply defined but not high; distance from anus to tip of female tail 55–70μ . . . . . *T. colubriformis*
   Spicules unequal 6
6. Spicules similar in conformation to those of *T. colubriformis*, shorter spicule 145μ long, longer spicule 157–172μ long; median side of each spicule provided with two long, thin appendages; female tail long and narrow . . . . . *T. retortaeformis*
   Right spicule about 85μ and left about 100μ long; right spicule narrowing abruptly about 65μ from proximal end; both spicules terminate in sharp points . . . . . *T. texianus*

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ENTOMOLOGY.—*Records of* Argynnis diana *and of some other butterflies from Virginia.*[1]

AUSTIN H. CLARK, U. S. National Museum, and CARROLL M. WILLIAMS, University of Richmond.

The great diversity of geographic conditions in Virginia is reflected in widely varying faunal conditions in different portions of the State. The low-lying eastern portion is a northeasterly extension of the Lower Austral life zone. The mountains in the west are characterized by a southwesterly extension of the Transition zone, with their highest summits, in the southwest, capped by Canadian "islands." Between the Lower Austral and Transition zones is a narrower strip of Upper Austral not very clearly differentiated—so far as the butterflies are concerned—from the Lower Austral.

The Lower Austral zone in Virginia presents some curious anomalies. Perhaps the most interesting of these anomalies is the occurrence in localized areas of species of butterflies characteristic of the Transition zone. Such species are *Argynnis diana, Satyrodes eurydice,* and the typical form of *Atrytone dion,* which seem quite out of place on the hot coastal plain. *Argynnis cybele,* common in the Upper Austral and Transition zones, also occurs here.

In these same areas *Enodia creola* is widespread and locally common, and *Amblyscirtes carolina* is almost everywhere present, though apparently never very numerous. *Enodia portlandia* and *Amblyscirtes textor* also are common here, but both of these range eastward to the sea.

Atrytone dion dion occurs in the cool boggy hollows between the sand dunes west of Cape Henry; the southern form, *A. d. alabamae,* occurs further to the northward, in the Dahl swamp in Accomac County. The other species are found, in more or less widely separated localities, along the western border of the Dismal Swamp and in and

[1] Received March 2, 1937.

near the swamps bordering the Blackwater and the Meherrin rivers.

We have thought it advisable at this time to call attention to this curious feature in the distribution of butterflies in Virginia in the hope that others may be stimulated to undertake investigations in this region. A very large number of records will be necessary before this and other anomalies in the distribution of the butterflies in the Virginian coastal plain can be properly interpreted.

Through the courtesy of a number of our colleagues we are privileged to include their records with our own. We are under special obligations to Prof. Ellison A. Smyth, Jr., of Salem (formerly of Blacksburg), Va.; to Prof. Lorande Loss Woodruff of Yale University, New Haven, Conn.; to Dr. G. W. Rawson, of Detroit, Mich.; to Mr. Herman J. Erb, of Ozone Park, N. Y.; to Mr. C. C. Walton of Richmond, Va.; and to Mr. W. Herbert Wagner, of Washington, D. C.

Argynnis diana.—The male of *Argynnis diana* was described and figured by Pieter Cramer in 1779. The locality he gave for his specimen was "Virginia."

The species was not again recorded from Virginia until 1895 when Prof. Ellison A. Smyth, Jr., wrote that it occurred in Montgomery County and "along the Blue Ridge," and in 1896 when Dr. Henry Skinner said that "the females found in eastern Tennessee, western North Carolina and southern Illinois are larger than those found in the mountains of Virginia."

In 1899 Sherman Denton mentioned its occurrence in "Western Virginia." In 1916 William C. Wood recorded it from Camp Craig, near Blacksburg, and Professor Smyth recorded it from Blacksburg and said that he had found it in Montgomery, Washington, and Giles Counties.

In 1934 and 1935 the senior author recorded it from Apple Orchard mountain in Bedford County.

The locality from which came Cramer's specimen still remained a mystery, for all the later records are from the mountains—territory but little explored in Cramer's time.

This butterfly has a much wider range in Virginia than one would be led to suppose from the few published records. It even occurs on the coastal plain. During the past summer the junior author took it south of Zuni and southeast of New Bohemia in the vicinity of the Blackwater river, and presumably it occurs elsewhere in this region.

Its occurrence here in the long settled portion of Virginia would explain satisfactorily how it happened that Cramer was able to secure a specimen, and we believe that eastern Virginia should be regarded as the type locality of the species.

The localities from which *Argynnis diana* is known in Virginia are:

BATH COUNTY: Warm Springs (G. W. Rawson); Hot Springs (Col. Wirt Robinson). ALLEGHANY COUNTY: Clifton Forge, July 5, 1936 (C. C. Walton). GILES COUNTY: (E. A. Smyth, Jr., 1916); Mountain Lake, July 1936 (L. L. Woodruff). BLAND COUNTY: Effna, July 19, 1936 (A. H. and L. F. Clark). DICKENSON COUNTY: Fremont, July 18, 1936 (A. H. and L. F. Clark). WASHINGTON COUNTY: (E. A. Smyth, Jr., 1916); Damascus, July 13, 1936 (A. H. and L. F. Clark); Konnarock, July 13, 1936 (A. H. and L. F. Clark). SMYTH COUNTY: Iron Mountain, July 10, 1936 (A. H. and L. F. Clark); Elk Gardens (Miss Umbarger); below Elk Gardens, July 11–13, 1936 (A. H. and L. F. Clark). PATRICK COUNTY: Blue Ridge Mountain, near Lovers' Leap, September 1, 1936 (A. H. and L. F. Clark). MONTGOMERY COUNTY: (E. A. Smyth, Jr., 1895, 1916); Blacksburg (E. A. Smyth, Jr., 1916); Camp Craig, near Blacksburg, taken by C. Harvey Crabill in August, 1914 (Wood, 1916); Poverty Hollow, near Blacksburg, 1933 (H. J. Erb). ROANOKE COUNTY: Salem (E. A. Smyth, Jr.). BEDFORD COUNTY: Apple Orchard Mountain (A. H. Clark, 1934, 1935). CHESTERFIELD COUNTY: (C. M. Williams). PRINCE GEORGE COUNTY: Southeast of New Bohemia, July 28, 1936 (C. M. Williams). ISLE OF WIGHT COUNTY: South of Zuni, August 22, 1936 (C. M. Williams). *Indefinite records:* Along the Blue Ridge (E. A. Smyth, Jr., 1895); Mountains of Virginia (Skinner, 1896); Western Virginia (=? West Virginia) (Denton, 1899); Virginia (Cramer, 1779).

Although this butterfly is widely distributed over the state it is very local, and in the places where it is found it occurs as a rule only in small numbers. Its favorite haunts are steep damp slopes and ravines where it keeps largely in the woods unless lured to the roadsides or into the open by the flowers of milkweed or ironweed.

Argynnis cybele.—This species, common in the piedmont region and in the mountains, was found south of Zuni, Isle of Wight County, on September 6, 1936 (A. H. and L. F. Clark).

Enodia creola.—This butterfly proves to have a fairly extensive range in eastern Virginia, flying usually, though not always, with *E. portlandia.* Unpublished records are: Near New Bohemia, Prince George County, June 22, 1936 (G. W. Rawson and W. H. Wagner); near Petersburg, Dinwiddie County, June 25, 1936 (C. M. Williams); near Zuni, Isle of Wight County, September 6, 1936 (A. H. and L. F. Clark); Emporia, Greensville County, August 19, 1936 (C. M. Williams). We have noticed, independently, that both this species and *E. portlandia* are invariably associated with the cane (*Arundinaria gigantea*) which we therefore believe is their food plant in eastern Virginia. Both species are curious in being normally more or less active in the evening until it becomes too dark to see them.

Satyrodes eurydice.—Unpublished records for this species are: Langley, Fairfax County, July 5, 1936 (A. H. and L. F. Clark); Difficult Run, Fairfax County, September 19, 1936 (W. H. Wagner); Richmond, Henrico

County, July 1, 1936 (C. M. Williams); Quinton, New Kent County, August 30, 1936 (C. M. Williams); Burks Garden, Tazewell County, July 19, 1936 (A. H. and L. F. Clark); and near New Bohemia, Prince George County, June 22, 1936 (G. W. Rawson and W. H. Wagner); Emporia, Greensville County, September 3, 1936 (A. H. and L. F. Clark).

Neonympha areolatus var. *septentrionalis*.—Apparently widely distributed, though very local, in the coastal plain and lower piedmont; new records are: Lunenburg, Lunenburg County, September 2, 1936 (A. H. and L. F. Clark); north and south of Emporia, Greensville County, August 19, 1936 (C. M. Williams); Courtland, Southampton County, August 25, 1936 (C. M. Williams); north of Factory Hill, August 26, 1936 (C. M. Williams); south of Petersburg, Dinwiddie County, August 25, 1936 (C. M. Williams).

Cercyonis alope ?pegala.—Dark males from 45 to 49 mm in expanse lacking the posterior eye spot in the yellow band on the fore wing, agreeing with those from New Jersey that are regarded by some as representing a dwarf form of *pegala*, have been taken south of Petersburg, Dinwiddie County, July 18, 1936; North of Cypress Bridge, July 23, 1936; and northeast of Homeville, Sussex County, July 29, 1936. These were compared with several specimens from New Jersey and with one (recorded as *pegala*) from the District of Columbia.

Strymon liparops form *strigosa*.—This butterfly has been taken by Mr. Herman J. Erb near Blacksburg in July.

Pyrgus centaureae wyandot.—Unpublished records for the State are: Hayfield, Frederick County, April 28, 1935, frequent (A. H. and L. F. Clark); Sexton Shelter, Skyline Drive, May 26 and June 2, 1935, frequent (W. H. Wagner); Blacksburg, Montgomery County (E. A. Smyth, Jr.).

Pholisora hayhurstii.—Found along the western border of the Dismal Swamp near Suffolk, September 4, 1936 (A. H. and L. F. Clark).

Hesperia metea.—Taken at Richmond, April 26, 1936 (C. M. Williams).

Hesperia leonardus.—New records are: Meadows of Dan, Patrick County, September 1, 1936 (A. H. and L. F. Clark); Big Meadows, Skyline Drive, August 27, 1933 (A. H. and L. F. Clark); Blacksburg, Montgomery County (E. A. Smyth, Jr.).

Hesperia sessacus.—Unpublished records are: Hayfield, Frederick County, May 17, 1936, common (A. H. and L. F. Clark); summit of Stony Man mountain, Page County, May 24, 1936 (A. H. and L. F. Clark); Blacksburg, Montgomery County, variable in abundance (E. A. Smyth, Jr.).

Atrytonopsis hianna.—New records for the State are: Clifton Forge, Alleghany County, May 12, 1936 (C. C. Walton); Warrenton, Fauquier County, May 24, 1936, frequent (A. H. and L. F. Clark); Richmond, Henrico County, May 12, 1936 (C. M. Williams); Glebe, Westmoreland County, May 31, 1936 (W. H. Wagner).

Atrytone logan.—New records are: South of Zuni, Isle of Wight County, August 20, 24, 1936 (C. M. Williams); north of Walters, Isle of Wight

County, August 22, 1936 (C. M. Williams); Clifton Forge, Alleghany County, July 26, 1936 (C. C. Walton).

Poanes viator.—Found in great abundance near Port Richmond, King William County, on June 7, 1936 (A. H. and L. F. Clark).

Amblyscirtes carolina.—This little skipper has approximately the same range within the State as *Enodia creola.* Unpublished records are: New Bohemia, Prince George County, June 22, 1936 (W. H. Wagner); Emporia, Greensville County, September 3, 1936 (A. H. and L. F. Clark); Cypress Bridge, July 23, 1936 (C. M. Williams).

Panoquina panoquin.—New records for this salt marsh skipper are: New Point, Mathews County, August 23, 1936 (A. H. and L. F. Clark); Lynnhaven, Princess Anne County, September 5, 1936, abundant (A. H. and L. F. Clark).

ANTHROPOLOGY.—*The finding of two ossuaries on the site of the Indian village of Nacotchtanke (Anacostia).*[1] T. D. STEWART and W. R. WEDEL, U. S. National Museum.

When Capt. John Smith ascended the Potomac river in 1608 he described an Indian village extending some distance along the eastern bank of a large tributary entering from the east near the head of navigation. To this village, "with 80 able men," Smith gave the name "Nacotchtanke" (Arber). Later the missionaries, who arrived on the Potomac in 1634, latinized this name to Anacostan (Tooker), whence is derived the present name of the river and city—Anacostia. Except for references to trade relations and skirmishes, both with the English and neighboring tribes, this village figures very little more in written history. The date of its abandonment is not certain, but it was probably during the middle or latter part of the seventeenth century. The Potomac region in general was abandoned by the Indians about 1700, according to Mooney.

There is some question as to the tribal affiliation of the inhabitants of Nacotchtanke. Mooney (map, pl. VII) considers them Algonkins and includes them in the Powhatan Confederacy, but notes that they received Smith peacefully, thus disobeying Powhatan's orders. According to the Handbook of American Indians, Shea considers this group Iroquoian.

In substantiation of the historical record regarding the location of Nacotchtanke are the reports of local collectors. In 1889 Proudfit stated (pp. 242–243):

[1] Approved for publication by the Secretary of the Smithsonian Institution. Received February 19, 1937.

These fields [from Giesboro Point on the south to within a short distance of Bladensburg on the north] have been under cultivation for many years, and are regularly visited by local collectors, yet they are today, in places, fairly strewn with the wreck of the old village life.

In addition to the stone relics . . . , it should be observed that an abundance of pottery, in fragments, is to be found—one of the unfailing evidences of permanent aboriginal occupation.

This statement seems to have been accepted by the investigators who have published subsequently, including Holmes and Ulke.

Since the above covers almost everything that is known regarding Nacotchtanke, it is of interest and importance to record the finding of two ossuaries at Giesboro Point during the past year. As is often the case, the burials were discovered accidentally. In the course of grading operations directed toward the extension of Bolling Field, the army flying field, a power-shovel exposed some human bones on September 11, 1936. The District coroner, Dr. A. Magruder MacDonald, was notified by those in charge of the work. He pronounced the bones to be those of Indians and ordered them saved; also, he notified the Smithsonian Institution.

On the morning of September 12 the senior author visited the site in company with F. M. Setzler, Acting Head Curator of Anthropology, U. S. National Museum. At this time a skull and a few bones, still remaining *in situ*, were removed. In the afternoon Dr. Wedel accompanied the senior author to the site. We were soon rewarded by the exposure of a second ossuary which we were permitted to excavate by our own methods. This operation, in which we were assisted by Robert Ladd of Washington, required the next two whole days. The details follow.

THE SITE

At the confluence of the Potomac and Anacostia the eastern shore (Fig. 1) is comparatively low-lying, forming an almost level plain between the rivers on the west and the hills to the east. At the time of our visit the grading operations were far advanced. Since some 7–8 feet of earth was being removed at the point where the ossuaries were located, it appeared that here a natural ridge of sandy soil extended in an east-west direction from the shoreline toward the hills. This agrees with the location of the ten-foot contour line on the Geological Survey map (Fig. 1).

Pit no. 1.—This was located some 150 yards from the river bank and about a quarter of a mile south from the line of the Portland

Street entrance to Bolling Field. Most of the bones had been removed by workmen and the power-shovel prior to our arrival and had been placed in barrels. From descriptions given by the laborers, as well as from the few bones left *in situ*, it appears that less than twelve inches of sandy soil covered the bones. The layer within which the latter

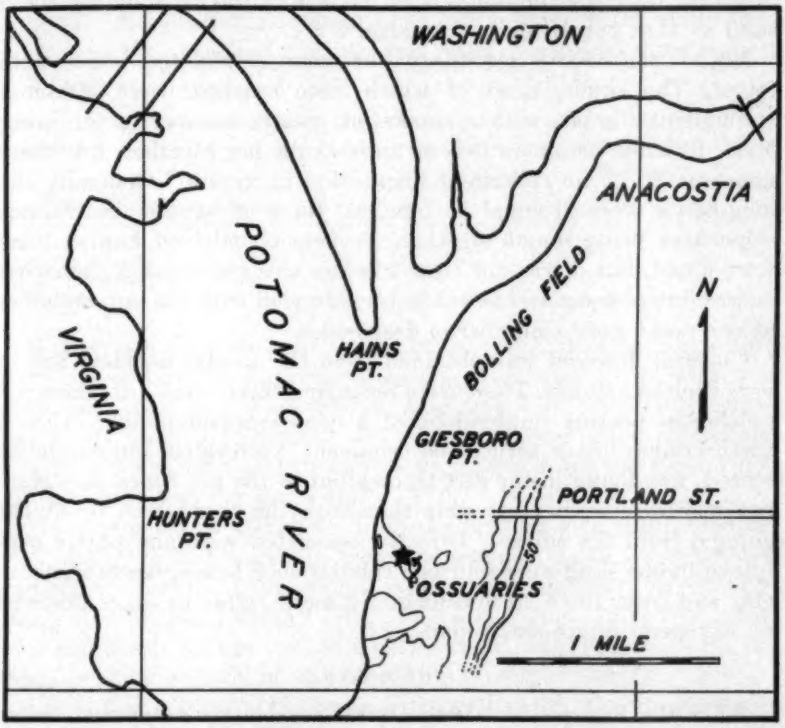

Fig. 1.—Map showing the location of the ossuaries and the topography in their immediate vicinity. (Based on the Geological Survey map of the District of Columbia, edition of 1929.)

were scattered was of about the same thickness. Owing to the uniformly sandy character of the surrounding soil and to its disturbance by machinery, efforts to define the original edge of the pit were unsuccessful. It was evident, however, that the area within which the remains occurred was not more than ten or twelve feet in diameter. No record was obtained of any cultural material having been seen.

Pit no. 2.—The second pit was encountered by the shovel at the time of our work and was completely excavated by hand. It lay some

50 or 60 yards due east of the first. The soil covering it was but a few inches deep, and there was some evidence that the uppermost bones had been broken and otherwise disturbed by plowing. No pit outline could be traced, but the bones occurred over an irregular area roughly fifteen feet in diameter and at a depth of six to eighteen inches. The "matrix" in which the bones occurred was of the same light colored sand as that constituting the ridge.

Burial was clearly secondary but some articulated bones were found. The skulls, most of which were crushed, were scattered throughout the pit, with a somewhat greater number in the lower level. In some instances two or more skulls lay together, but there appeared to be no consistent disposition in "nests." Generally the long-bones were grouped in bundles, those of several individuals sometimes being found together. Pockets of calcined human bone were noted, but it was not clear whether this represented cremation or was due to some accidental factor. Mingled with the human bones at one point were a number of deer bones.

Cultural material was obtained from the second ossuary, but in very limited amount. There were recovered three small grit-tempered potsherds, bearing impressions of a cord-wrapped paddle. Also, a small crudely made serpentine ornament, perforated and carelessly scored, was found in the dirt thrown out of the pit. Since they were not seen *in situ*, it is possible that both the sherds and ornament entered from the surface. Directly associated with and partly contained in one skull were fourteen tubular shell beads, 6 mm in diameter and from 10 to 20 mm long. No metal, glass or other material of European origin was found.

THE BONES

Since the first pit had been almost completely excavated before our arrival, we could not hope to recover many whole bones for the Museum collections. Alternatively, we limited our collection to those parts of more particular interest, namely, the temporal bone, jaws and teeth, distal end of the humerus, proximal end of the femur, pathological and anomalous bones. The same policy was adopted in selecting bones from the second pit, but here fortunately the method of excavation permitted the recovery of more whole bones. A count of the temporal bones, humeri, and femora from the two pits (Table 1) gives some reason for believing that approximately the same number of individuals was buried in each. This number is above 63 but is not likely to have been more than 70. The smaller number of tem-

poral bones recovered from the first pit may be explained by the fact that the workmen and others removed the skulls for souvenirs before our arrival. The excess of temporal bones in the second pit may possibly mean that more skulls than extremities were interred. However, it should be remembered that, when broken, the parts of the long-bones are more difficult to identify than the parts of the skull. It is quite possible, therefore, that we may have overlooked some humeri and femora.

TABLE 1.—NUMBER OF BONES RECOVERED FROM OSSUARIES

Bone	Pit No. 1		Pit No. 2	
	Right	Left	Right	Left
Temporal	39	38	63	63
Humerus (distal)	56	36	49	39
Femur (proximal)	50	47	48	40

It is certain from an examination of the bones that both sexes are represented, but not disproportionately. According to the stages of dentition shown in the lower jaws, adults predominate. Four immature lower jaws, the youngest 2–6 years old, were found among the bones from the first pit. Of twelve such jaws from the second pit, the youngest was 1–2 years old.

Measurements of two skulls from the first pit give cranial indices of 68.3 and 71.9. Nine skulls from the second pit, all reconstructed and mostly female, have cranial indices ranging from low dolichocrany to high brachycrany (72.6, 72.7, 75.1, 75.6, 75.7, 77.3, 79.4, 84.0 and 86.0). Except for the most extreme brachycranic skull, the range is characteristic of the Algonkins (Hrdlička, 1927).

Two other features of the bones indicate that the inhabitants of this site were typical eastern Indians. Ear exostoses are present in 10 per cent of the ears (169), which is only slightly higher than the figure (8.5) reported by Hrdlička (1935) for the Indians north of Virginia. Septal apertures of the humerus are present in 43.2 per cent of the cases (134), and this too agrees well with the figure (40.4) reported by Hrdlička (1932) for the eastern Indians. These similarities become more impressive when it is realized how different are the figures for other Indian tribes. For example, among the Sioux the incidence of ear exostoses rises to 22 per cent, whereas that of septal aperture falls to 21.5 per cent (Hrdlička, 1932, 1935).

Among the pathological bones recovered were a number, mostly tibiae, bearing lesions generally regarded as having been produced

by syphilis. It is noteworthy that more of these bones occurred in the first pit, in which also the bones were somewhat better preserved. Another, but minor, pathological condition to which these Indians were extremely susceptible was dental caries.

DISCUSSION

The finding of two ossuaries at Giesboro Point is further evidence of a habitation site in the vicinity. According to historical record this was Nacotchtanke. Although nothing is known of the limits of this village at the time the burials were made, it is reasonable to believe that it was not very far away—perhaps to the north. It is probable also that originally the burials were deeper, and it is possible even that a low mound was raised over them. The ultimate shallow position of the bones may be accounted for through the farming operations to which this area was subjected later. The number of individuals buried in these pits probably has some relationship to the population of the village, but the time interval involved is not known.

The chief reason for reporting these ossuaries is that they indicate some of the burial customs prevailing in this region. When Bushnell, in 1920, reviewed these customs for the Powhatan Confederacy, he knew of only one site at which ossuaries had been found. Since then, in 1935, Judge Graham has reported a group of four ossuaries found at Potapaco (now Port Tobacco), another site marked on Smith's map.

The senior author had the pleasure of assisting Judge Graham in excavating the pits at Port Tobacco, so he was in a position to make comparisons between the two sites. Briefly, it may be said that in appearance the burials were very similar, making due allowance for differences in soil. The scarcity of cultural material in the Anacostia pits is in contrast to those at Port Tobacco. Nevertheless, the type of cultural material encountered—beads, ornaments—is still consistent with Smith's statement (quoted from Bushnell, p. 28) that,

> For their ordinary burial they digge a deep hole in the earth with sharpe stakes; and the corpses being lapped in skins and mats with their jewels, they lay them upon sticks in the ground and so cover them with earth.

While it is not clear what Smith meant by the term "corpses," it is possible that he is referring to bodies that have been allowed to decompose in a charnel house. At Port Tobacco remnants of skins and mats which had been preserved by copper were found associated with the bones in the fourth pit. The finding of calcined bone in the second

pit at Anacostia is something new for this area and cannot be clearly explained.

The occurrence of pathological bones in the pits, both at Anacostia and at Port Tobacco, with lesions resembling syphilis may be interpreted in different ways depending on whether or not syphilis is proved to be a pre- or post-Columbian disease. If pre-Columbian, this finding is of little significance historically. However, if post-Columbian, then these burials would date from the historic period and the different incidence of diseased bones in the two pits would take on more meaning. The absence of associated European objects is not contrary to the possibility that syphilis is a post-Columbian disease; it could have preceded Smith to this region.

Skeletal remains are rapidly being accumulated from Maryland and Virginia. Already it is recognized that a rather uniform physical type existed among the eastern Indians. Detailed study of this material eventually should indicate the closer physical affiliations of the various bands.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

540TH MEETING

The 540th meeting was held in the Assembly Hall of the Cosmos Club, April 8, 1936, Vice-President R. C. WELLS presiding.

Informal communications.—T. A. HENDRICKS discussed obtuse-angled cone-in-cone structures from the Missouri Mountain slate of Arkansas.

Program.—A. J. EARDLEY: *Silts of the lower Yukon valley.*

T. S. LOVERING: *Origin of the telluride ores of Boulder County, Colorado.*

541ST MEETING

The 541st meeting was held in the Assembly Hall of the Cosmos Club, April 22, 1936, Vice-President H. D. MISER presiding.

Informal communications.—L. W. STEPHENSON: *Flat-bottomed stream erosion by wetting and drying.* Little Walnut Creek is a small, intermittent tributary of Walnut Creek which joins Colorado River a few miles east of Austin, in Travis County, Texas. Little Walnut Creek heads in the belt of outcrop of the Austin chalk about 8 miles north of Austin, and flows within that belt in the upper 5 miles of its course. In a stretch a thousand feet or so long, above the iron bridge at the old Sprinkle road crossing (abandoned), 5 miles northeast of Austin, the stream has cut its channel some 15 or 20 feet deep and 70 to 75 feet wide in a rather hard, massive, uniform facies of the chalk. About 300 feet upstream from the bridge a normal fault drops stratigraphically higher and softer beds of the chalk down against the harder facies. The gradient steepens sharply just above the fault as the stream passes from the harder to the softer beds.

In its course through the harder facies of the chalk, including the descent from this facies to the softer facies below, a transverse profile of the stream bed is so nearly level that water when present is distributed with almost perfect uniformity across its entire width. When I visited the locality on November 20, 1935, the water was low and was so evenly spread that I waded the stream, scarcely wetting more than the soles of my boots.

In the case of a stream cutting its channel by abrasion it is to be expected that the part of the bed carrying the swiftest current will be most deeply eroded. In Little Walnut Creek abrasion is an insignificant factor in the process of erosion, as the stream is carrying little or no sand to serve as a cutting tool; solution may play a part in the process, but is probably a minor factor; fragmentation of the brittle chalk, caused by successive wetting by rainwater and drying, is believed to be the effective agent of erosion; the products of this process are easily swept away by occasional flood waters.

When water is present in the channel the chalk is protected from the wetting and drying process and is not eroded; the banks on either side are subjected to the process and are gradually eaten back down to water level; any part of the stream bed that may for any reason rise above water level is subjected to wetting and drying and is quickly reduced to the level in which wetting will protect it. When there is no water in the creek fragmentation due to wetting by occasional local showers and subsequent drying, will take place uniformly across the channel, thus maintaining its level profile.

Fragmentation of chalk by wetting and drying is an important erosion process in the channels of many of the streams crossing the chalk formations of the Gulf Coastal Plain. (*Author's abstract.*)

CLYDE P. ROSS described etched limestones in the Brazier limestone, Borah Peak Quadrangle, Idaho.

Program.—J. P. MARBLE: *Age of monazite from Mars Hill, North Carolina.* Analyses of a specimen of monazite from Mars Hill, N. C., for lead, thorium, and uranium, indicate an approximate age of 584 million years, or uppermost pre-Cambrian. Radiographs showed the mineral, a portion of the extremely large crystal collected by Schaller, to be relatively fresh and unaltered. The age found is in reasonable agreement with the field evidence. As the mineral is extremely low in uranium, further studies are projected.

G. A. COOPER: *Devonian correlations in Michigan and Ontario.*

SPECIAL MEETING

A special meeting was held in the Assembly Hall of the Cosmos Club, April 29, 1936, Vice-President H. D. MISER presiding.

Informal communiations.—JOSIAH BRIDGE remarked on the productive and illustrious life of Dr. A. F. Foerste, recently deceased.

D. F. HEWETT remarked on the life and work of H. D. McCaskey, recently deceased.

Program.—C. H. BEHRE, JR., Northwestern University: *Geologic History of South Park, Colorado.*

FRANCIS P. SHEPARD, University of Illinois: *Evidence of a greatly lowered sea-level.*

542ND MEETING

The 542nd meeting was held in the Assembly Hall of the Cosmos Club, October 28, 1936, President M. I. GOLDMAN, presiding.

Program.—ROBERT F. GRIGGS, George Washington University: *Timberlines as indicators of climatic trends.*

GEORGE TUNELL and C. J. KSANDA: *Some general conclusions from investigations of the calaverite group.* The peculiar face development of calaverite crystals, which has been known since 1895, was discussed in relation to the crystal structure of calaverite (determined by the authors). Certain adventive (non-structural) diffraction planes were correlated with the complex faces. Although a complete explanation of the complex faces and adventive diffraction planes has not yet been found, sufficient progress has been made to indicate that these peculiarities of calaverite will not lead to an alteration in the theory of space-groups or the law of simple rational indices, but are rather to be conceived as due to some type of subidiary phenomenon in the crystals. (*Author's abstract*).

WENDELL P. WOODRING: *Depositional environment of Lower Pliocene oil-bearing formations of the Los Angeles Basin, California.*

543RD MEETING

The 543rd meeting was held in the Assembly Hall of the Cosmos Club, November 11, 1936, President M. I. GOLDMAN, presiding.

Informal communications.—J. B. REESIDE, JR., reviewed criticisms of Lauge Koch by eleven of his contemporaries.

M. I. GOLDMAN reported on a statement by de Margerie regarding the criticism by a group of Danish geologists of the work of Lauge Koch (from C. R. somm., no. 6, p. 97, 1936) as follows: The manifesto carrying the signatures of a dozen geologists, Scandinavian and German, criticizing the work of Lauge Koch in Greenland, has in effect no less an object than to discredit the methods of the eminent explorer. Overlooking the invaluable services which Koch has rendered to the study of the Artic regions, these gentlemen pick out trivial errors such as can be found in every human product and

overlook the outstanding discoveries by which he has enriched and transformed in such large measure the picture of the geology of Greenland that one of the signers, Böggild, drew 20 years ago. They even go so far as to reproach the Danish scientist for having had recourse to the airplane for completing his reconnaissance. There is here a lack of perspective which is positively shocking and one which a purely objective comparison of the texts cannot fail to bring out. It is hard to see what science gains by attacks so evidently biased.

C. B. HUNT described a method for obtaining data on total precipitation over an extended period of time.

Program.—J. B. MERTIE, JR., *Glacial features of the Nushagak district, Alaska.* The Nushagak district lies in a remote and little-visited part of southwestern Alaska. The Tikchik Mountains of this district are of particular interest because they are the site of a Pleistocene ice cap which covered an area of 6,000 square miles or more but was not a part of the great ice fields of the Alaska Range and contiguous territory.

The central part of the Tikchik Mountains is a rugged fretted upland, composed of comb ridges, pinnacle-like peaks, and high alpine valleys that show all the marks of severe and long-continued glaciation. Along the eastern side of these mountains is a system of twelve nearly parallel lakes from 7 to 35 miles in length, of which ten are connected together into two systems of interlake drainages that discharge eastward and southward. The present Nushagak Valley, which lies east of these lakes, is a great desolate, swampy lowland, composed of glaciofluviatile and outwash deposits which issued from the glaciated mountainous area.

The border lakes, though originally barrier lakes, now occupy essentially bedrock basins, and are classified as alpine glint lakes. They have depths ranging from 340 to 930 feet and in their deepest places reach from 300 to 600 feet below sea level. A number of these lakes have narrow fiord-like headwater bays which are separated from the main lakes by bedrock constrictions or barriers but are as deep as, or deeper than, the main lakes. Both the headwater bays, and the main lakes below these bedrock constrictions, increase rapidly in depth to the maximum, then gradually become shallower toward their lower ends, terminating in bedrock shoals, islands or barriers. It is possible that the headwater bays indicate either a pause in the retreat of the ice sheet, or a very late rejuvenation of glaciation.

All the usual physiographic features that are associated with severe glaciation are found in the country surrounding these lakes. These features include glacial scouring and plucking, steep-walled U-shaped cross sections, and well-developed cirques in hanging valleys, in the upper parts of the lakes; and morainal deposits at the lower ends of the lakes. Postglacial erosion is relatively slight close to the higher mountains but is perceptibly greater in the lower hills to the east. Another significant physiographic feature is a system of rather well-developed postglacial lake terraces, ranging in elevation from 5 to 65 feet above present lake levels.

The ancient valleys, now partially filled by these lakes, were occupied in preglacial time by alpine streams, but in their lower reaches had higher gradients than at present. This deduction is based upon drill-hole records at tidewater, where the outwash fill is known to have a thickness of 200 feet or more. The present interlake drainage was caused by the alluviation of these ancient valleys by morainal and outwash deposits that were laid down as the ice tongues retreated. This alluviation finally raised local base levels of ero-

sion sufficiently to cause the lakes to spill over into one another, thus establishing the present abnormal system of interlake drainages. The various lake terraces record not only the maximum magnitude of this alluviation, but also the subsequent sequence of lowering of the lake levels. (*Author's abstract.*)

J. C. REED: *Significance of amygdales in Columbia River lava.* Periodic tilting of a fault block in north-central Idaho is reflected by the convergence of bands of silica that fill large gas cavities in lava. The fault block, the Whitebird block, is about 15 miles long and 12 to 15 miles wide. It is bounded on its east and west sides by normal faults. The lava series of about 35 flows with some interbedded unconsolidated sediments that constitute the upper 2,600 feet or more of the block is tilted to the northwest at 17 degrees.

The bands of silica in the filled cavities, or amygdales, consist of alternating layers of quartz and mixed opal and quartz. The bands were apparently deposited horizontally under the influence of gravity. The convergence of the bands indicates tilting of the block between times of deposition of the bands. The amygdales that were examined show a maximum convergence of bands of 14 degrees or reflect almost the complete tilting history of the block.

Between the rock around the amygdales and the banded interiors is a zone of concentric layers that ranges from less than a millimeter to more than 10 millimeters thick. The sequence of these concentric layers in all the amygdales examined in order from the outside toward the interior is nontronite, greenalite, melanophlogite, erionite, chalcedony, and mixed chalcedony and opal. The minerals were determined by their optical properties, which should be checked by other methods. The concentric layers probably were deposited by deuteric emanations long before the banded interiors were laid down from supergene solutions. (*Author's abstract.*)

JOINT MEETING

A joint meeting with the Washington Academy of Sciences was held in the Assembly Hall of the Cosmos Club, November 19, 1936, President O. E. MEINZER, of the Washington Academy of Sciences, presiding.

Program.—GEORGE H. ASHLEY, State Geologist of Pennsylvania: *The emergence of ideas as illustrated from Geology.*

544TH MEETING

The 544th meeting was held in the Assembly Hall of the Cosmos Club, November 25, 1936, Vice-President H. D. MISER presiding.

Program.—Testimonials for the late Dr. David White of the United States Geological Survey, by H. D. MISER, W. C. MENDENHALL, CHARLES BUTTS, F. E. WRIGHT, K. C. HEALD, and E. W. BERRY.

545TH MEETING

The 545th meeting was held in the Assembly Hall of the Cosmos Club, December 9, 1936, President M. I. GOLDMAN, presiding.

GEORGE TUNELL, chairman of the committee to select the first and second best papers delivered before the Society during the year, announced that W. P. WOODRING was awarded first prize and E. T. ALLEN second prize.

Vice-President R. C. WELLS took the chair during the presentation of Mr. Goldman's presidential address: *Petrographic features of salt dome cap rock.*

44TH ANNUAL MEETING

The 44th Annual Meeting was held in the Assembly Hall of the Cosmos Club after the adjournment of the 545th regular meeting, President M. I. GOLDMAN presiding. The annual report of the secretaries was read. The treasurer then presented his annual report showing an excess of assets over liabilities of $1,319.48 on December 9, 1936. The auditing committee reported that the books of the treasurer were correct.

The results of the balloting for officers for the ensuing year were as follows: President, R. C. WELLS; Vice-Presidents, F. C. CALKINS, H. D. MISER; Treasurer, A. H. KOSCHMANN; Secretaries, G. A. COOPER, M. N. BRAMLETTE; Members-at-large-of-the-Council, R. W. BROWN, W. S. BURBANK, C. H. DANE, EARL INGERSON, J. C. REED; Nominee for Vice-President of the Washington Academy of Sciences representing the Geological Society, W. T. SCHALLER.

G. A. COOPER, *Secretary.*

Obituary

BENJAMIN LINCOLN ROBINSON, who a few years ago retired from the Asa Gray Professorship of Systematic Botany, which he had held since 1900, died July 27, 1935. He was born in Bloomington, Illinois, November 8, 1864, and received his A.B. degree from Harvard College in 1887. After taking his Ph.D. degree at Strasburg in 1889 he returned to Harvard University as assistant in the Gray Herbarium and became its curator in 1892, which position he held until he retired. With others he was an editor of *Synoptical flora of North America* from 1892 to 1897. He was editor of *Rhodora*, the journal of the Northeast Botanical Club, from 1899 to 1928, and also editor of the seventh edition of Gray's *New manual of botany*. He was the author of many published papers upon the classification and distribution of the spermatophytes of the United States, Mexico, northern South America and the Galapagos Islands. He was awarded a bronze medal at the Louisiana Purchase Exposition held in St. Louis, 1904, and the Centennial Gold Medal of the Massachusetts Horticultural Society in 1929 "for eminent service to botany." Besides being a member of the Washington Academy of Sciences and the National Academy of Sciences, Professor Robinson was a member of seventeen other American and foreign scientific societies. He was president of the Botanical Society of America in 1900, president of the Northeast Botanical Club from 1906 to 1908, and honorary member of the Chilean Society of Natural History.

CHARLES HENRY SMYTH, JR., emeritus professor of geology at Princeton University, died at the Princeton Hospital, April 4, 1937, from pneumonia and complications resulting from a fractured hip received in a fall two weeks previously.

Doctor Smyth was born at Oswego, N. Y., March 31, 1866. He received the Ph.B. degree in 1888 and the Ph.D. degree in 1890 from Columbia University. He studied at Heidelberg, Germany, 1890-1891. From 1891 to 1905 he was professor of geology and mineralogy at Hamilton College, and from 1905 until his retirement in 1934 he was professor of geology at Princeton University. His chief scientific contributions related to the Clinton type of iron ore, the regional geology and mineral deposits of the northwest Adirondacks, the origin of alkali-rich igneous rocks, and problems of chemical geology.

Doctor Smyth held membership in the American Association for the Advancement of Science, Geological Society of America, Philosophical Society, New York Academy, and Washington Academy of Sciences.